This chapter consists of three sections that address stormwater management at varying scales from individual lots to the entire watershed. The three sections are:

Section 3.1 Identifies a Green Infrastructure Plan, which is a water resources-based open space plan designed to protect stream and wetland resources from direct modification and intrusion.

Section 3.2 Describes BMPs in various categories, including policy/regulations, planning/zoning, stormwater management, and landscaping.

Section 3.3 Illustrates conservation site design templates for various types of developments. These templates demonstrate how site planning can be used to integrate retention-based stormwater Best Management Practices throughout the site. A "distributed stormwater management approach" is used rather than a more typical "end of the pipe approach".

3.1 Green Infrastructure Plan

A "green infrastructure plan" is essentially a water resources-based open space plan designed to protect stream and wetland resources from direct modification. The Plan indicates the most appropriate location for open space designation for the purpose of protecting and enhancing the watereshed's aquatic resources and creating an ecologically functioning network of open space. The intent is to maintain stream and wetland systems and complexes and to minimize fragmentation of habitat as the watershed develops.

The Criteria

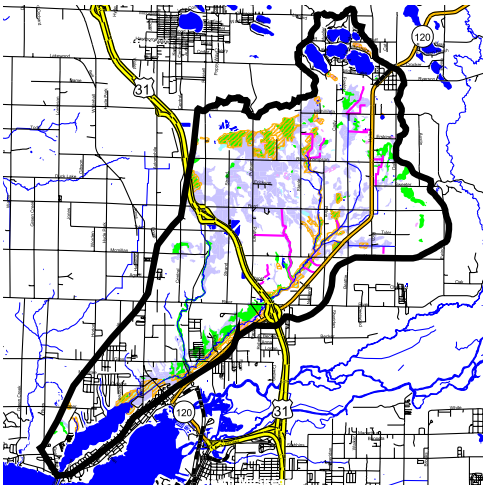
The following criteria were used for delineation of the Green Infrastructure Plan in the Bear Creek and Bear Lake Watershed.

Primary Criteria - The following features were identified as the primary areas to be protected.

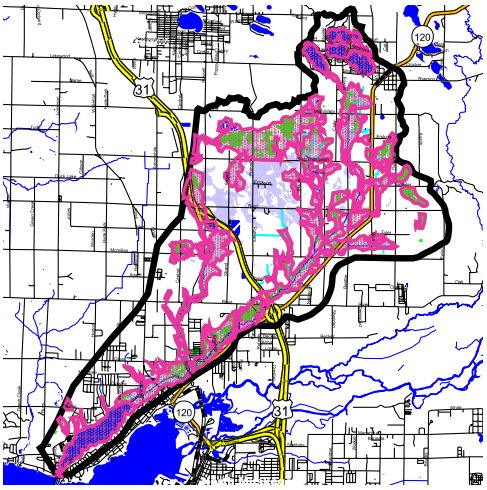
- Floodplains
- Minimum 100-foot buffers along streams and 50-foot buffers around wetlands and lakes
- Steep Slopes and erodible soils as identified in the soils analysis

Secondary Criteria - The following criteria were used to create networks and complexes from the individual features above.

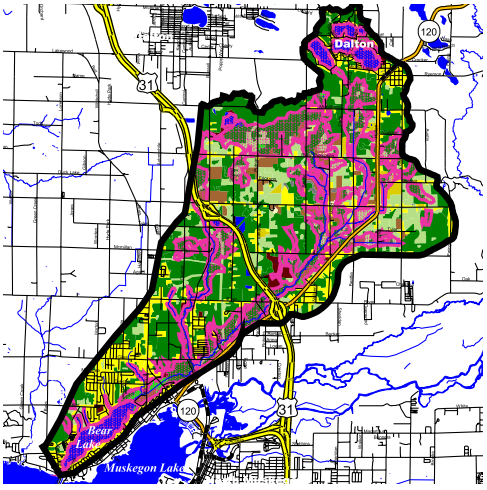
- Large areas of semi-contigious wetlands were aggregated into larger complexes by including land between the wetlands based on hydric soils and topography
- Isolated wetlands were connected along natural drainage corridors as interpreted from hydric soils and topography
- Existing built lands that would have been included based on the above criteria were excluded (including residential, commercial, industrial, and other developed areas identified in land use analysis in **Section 2.4**)



Step 1: Identify primary and secondary water resource features



Step 2: Outline the Plan based on water resource features



Step 3: Refine the Plan by excluding existing developed areas from the Plan boundary

The Process

The following steps outline the process followed during development of the Green Infrastructure Plan.

Step 1: Identify water resources and natural features

The purpose of this step was to identify all the major watersheds elements to be considered in the Green Infrastructure Plan. The primary features to be protected were floodplains, streams, lakes, wetlands, steep slopes, and erodible soils. Secondary features to be used to connect primary features were hydric soils.

Step 2: Outline Green Infrastructure Plan based on hydrologic and sensitive natural resources

After identifying the major elements to be protected, the next step was to outline a preliminary Green Infrastructure Plan. The process included identifying groups of isolated wetland areas and other features and delineating connections and corridors to establish complexes and an ecological network. The connections were made based on hydric soils and topography.

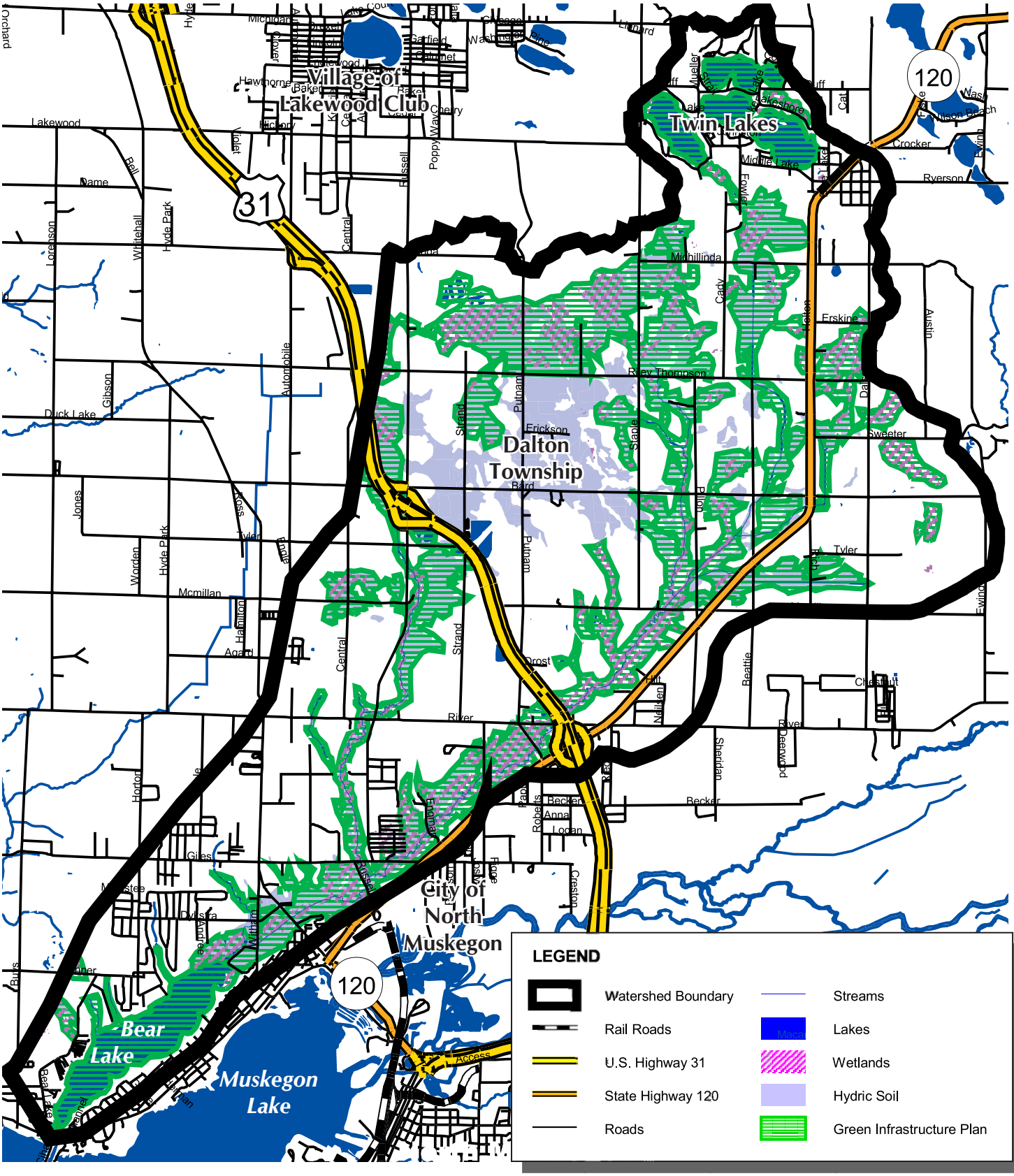
Step 3: Refine Green Infrastructure plan by excluding existing developed areas

After delineating a preliminary Green Infrastructure Plan, the final step was to refine the plan to ensure that existing built lands, such as residential, commercial, industrial and other developed land uses, were excluded from the Plan boundary. Excluded lands were identified based on the 1997 land use/land cover map.

Results

The resulting Green Infrastructure plan is shown on the facing page. The most significant contigious portion of the Plan is in the upper headwaters, south of the Twin lakes area where the tributaries are broadly distributed and wetlands and hydric soils extensively dominate the landscape. Much of this area was identified as remaining in cropland and forest in the Build-Out Analysis in **section 2.4**.

Because this document is intended to be a Stormwater Plan, non-water resource-based features were not included in the Green Infrastructure delineation process. To more comprehensively protect watershed ecological resources, it is



0 6000 12000 ft

scale:1 in = 6000 ft

North

Green Infrastructure Plan

recommended that significant upland natural areas also be included in the plan. These areas may include remnant forests, woodlands, and prairies, and historic and other cultural features. In addition, trail networks, parks environmental learning centers could be integrated in this Green Infrastructure Plan.

To implement the Green Infrastructure Plan, the following actions should be conducted:

- Delineate the open space network on existing and future land use plans,
- Develop zoning and subdivision codes to support the Green Infrastructure Plan,
- Pursue permanent protection of key resource areas within the open space network through purchase of development rights or conservation easements, and
- Develop a management plan for preserving and enhancing areas within the open space network.

While the green infrastructure plan identifies significant natural features and delineates recommended conservation areas at a regional scale, measures must be implemented at the site scale as well. Individual developments should be designed to protect on site natural features and open space that occurs outside the Green Infrastructure boundary and follow conservation site design principles. The BMP toolbox of **Section 3.2** and the site design templates of **Section 3.3** provide guidance on watershed protection strategies that should be implemented at the site scale.

3.2 Stormwater Best Management Practices Tool Box

The Stormwater Best Management Practices Tool Box identifies strategies and provides guidelines for stormwater management and water quality related practices that may be implemented in the Bear Creek and Bear Lake Watershed. The identified BMPs include ecologically and hydrologically sensitive designs, strategies, techniques, and practices that should be included in an overall watershed protection program. The stormwater BMPs presented in this section are multi-dimensional stormwater practices that meet traditional water quality and quantity standards outlined in many stormwater ordinances, as well as achieving planning, urban design, and landscaping objectives.

The BMPs presented in this section are designed to address both the quantity and quality of runoff from developed sites. The sandy soils of the Bear Creek and Bear Lake Watershed provide both opportunities and constraints. While infiltration-based stormwater management practices are well suited to this watershed, caution must be exercised to prevent contamination of groundwater resources in an effort to protect surface water resources. The keys to preventing groundwater contamination are to limit potentially polluting land uses to those areas least susceptible to groundwater contamination, implementing measures to prevent hazardous materials from coming in contact with rainfall and runoff, and to combine filtration measures with infiltration practices to filter common stormwater pollutants in all developed areas. This issue is addressed further in **Section 4.2**, which identifies management unit-specific opportunities, constraints, and recommendations.

The two tables on pages 7 and 8, respectively indicate; 1) the suitable scales and applicable development types for which each of the BMPs is most appropriate, and 2) the potential effectiveness of each BMPs in achieving a number of watershed goals and objectives. The BMPs are classified into four categories: policy/regulations, planning/zoning, site stormwater BMPs, and landscaping.

The presented stormwater BMPs can either be retrofitted into existing developed areas or integrated into new development through conservation planning and design. Templates that illustrate site level conservation planning and design are provided in **Section 3.3**. These BMPs can be used by local authority, planners, designers, engineers, and developers throughout the watershed.

Policy Actions/Regulations

Policies and Regulations serve as the first step to establish and then enforce minimum standards for natural resource protection and stormwater management. Policies express goals for natural resource, water quality, habitat, and open space protection. Regulations (along with zoning described below) are the tools used to implement the policies. Policy actions or regulations include acquisition of Conservation Easements, Stream/Wetland Restoration and Management, and adoption of Watershed Development Ordinances.

Planning/Zoning

Planning/Zoning related practices are also used to implement policy goals of maintaining high environmental quality as a watershed develops. Significant natural features and other areas to be protected are identified using environmental planning processes. Many of these areas can then be protected through open space and other protective zoning. Open Space/Natural Greenway delineation, Riparian Buffers, and Floodplain Zoning are tools used to protect natural resource areas from development. Conservation Development and Impervious Area Reduction are critical site level planning and design strategies to create environmentally sensitive developments to achieve stormwater management and watershed goals.

Site Stormwater BMPs

Site Stormwater BMPs are site-specific practices that minimize on site and off site hydrologic and water quality impacts due to stormwater runoff by attempting to incorporate and re-establish natural hydrologic processes into the built environment. These measures can be designed and implemented in new developments as well as retrofit into existing development in cost effective ways. Site stormwater BMPs have the capability to significantly improve the quality of stormwater runoff as well as quality of life. The practices discussed here include Bioswales, Filter Strips/Level Spreaders, Green Roofs, Naturalized Detention, Porous Pavement, Rain Barrels/Cisterns, Rainwater Gardens, and Vegetated Swales.

Landscaping

Landscaping, as a BMP, stands alone in its own category due to the importance of vegetation in biodiversity, aesthetics, habitat, cooling of ambient air, nutrient management and stormwater management. Native landscapes, including native prairies and wetlands, can improve water quality through infiltration and cleansing of stormwater runoff by the process of trapping sediments and removing nutrients. Properly designed landscapes that incorporate native plants and hydrologically and ecologically appropriate vegetation can serve to facilitate effective of stormwater management while providing wildlife habitat and quality open space.

Stormwater BMP Guidelines

The following pages illustrate each BMP by providing a definition, identifying its applicability, presenting associated benefits, and finally outlining design considerations.

A detailed description of these specific discussion categories follows:

Definition - a brief description of the BMP relative to stormwater management.

Applicability - Where and how each BMP is most applicable. BMP's are addressed in three aspects: scale, applicable situations, and effectiveness.

Scale

- **Watershed/County:** Applied at the regional scale such as watershed or county.
- **Municipal/Township:** Applied at the municipal or township scale where there is common zoning authority.
- **Neighborhood:** Applied at development or other sub-municipal scale.
- **Lot:** Applied within individual residential lots or commercial parcels.

Applications

- **Retrofit:** Applied to existing developed areas, infill, and redevelopment.
- **New:** Applied to new development.
- **Roofs:** Applied on roofs or used to treat roof runoff.
- **Streets:** Applied on or used to treat runoff from public/private streets and roads.
- **Driveways:** Applied on or used to treat runoff from driveways.
- **Parking Lots:** Applied on or used to treat runoff from parking lots.
- **Lawns:** Used to treat runoff from existing open lawns that are commonly planted with turf; such as parks, campuses, individual yards, etc.
- **Sensitive Areas:** Applied on ecologically sensitive areas such as remnant habitats, floodplains, wetlands, steep slopes, and highly erodible soils.

Effectiveness

- **Runoff Rate Control:** Practices that control or reduce runoff rates.
- **Runoff Volume Control:** Practices that control or reduce runoff volumes.
- **Physical Habitat Preservation/Creation:** Practices that preserve, introduce, or provide wildlife habitats.
- **Sediment Pollution Control:** Practices that remove suspended solids from runoff.
- **Nutrient Control:** Practices that have the ability to reduce or remove nutrients such as nitrogen and phosphorus from runoff.
- **BOD Control:** Practices that can remove constituents that exert a Biological Oxygen Demand (BOD) in runoff.
- **Other Pollutant Control:** Practices that can reduce and remove other pollutants such as heavy metals and petroleum based hydrocarbons.

Benefits - Positive effects that the individual or system of practices perform. Benefits can be specific to stormwater management or be more general to various functions and values related to quality of life.

Design Considerations - Design recommendations and suggestions that should be considered when implementing the specific BMP. Drawings are not illustrated for construction, but rather as general guidance on the components of the practice.

Bear Creek Watershed Stormwater Management Tool Applicability

Tools	Scale				Applications							
	Watershed/ County	Town/ Village	Neighbor-hood	Lot	Retrofit	New	Roofs	Streets	Drive-ways	Parking Lots	Lawns	Sensitive Areas
Policy/Regulations												
Conservation Easement	X	X	X	X	X	X						X
Stream/Wetlands Management and Restoration	X	X	X	X	X	X						X
Watershed Development Ordinance	X	X			X	X	X	X	X	X	X	X
Planning/Zoning												
Conservation Development	X	X	X			X		X	X	X	X	X
Floodplain Zoning	X	X			X	X						X
Impervious Area Reduction		X	X	X	X	X	X	X	X	X		
Open Space/Natural Greenway	X	X	X		X	X						X
Riparian Buffer	X	X	X	X	X	X					X	X
Site Stormwater BMPs												
Bioswales			X	X	X	X		X		X		
Filter Strips/Level Spreaders			X	X	X	X	X		X	X	X	X
Green Roofs				X	X	X	X					
Naturalized Detention	X	X	X		X	X	X	X	X	X	X	X
Porous Pavement			X	X	X	X		X	X	X		
Rain Barrels/Cisterns				X	X	X	X					
Rain Gardens				X	X	X	X	X	X		X	
Vegetated Swales			X	X	X	X	X	X	X	X	X	
Landscaping												
Native Landscaping			X	X	X	X	X	X	X	X	X	X

"X" = practices that are applicable to corresponding scale and applications

Bear Creek Watershed Stormwater Management Tool Effectiveness

Tools	Effectiveness						
	Runoff Rate Control	Runoff Volume Control	Physical Habitat Preservation/ Creation	Sediment Pollution Control	Nutrient Control	BOD Control	Other Pollutant Control
Policy/Regulations							
Conservation Easement	-	-	H	-	-	-	-
Stream/Wetlands Management and Restoration	M	M	H	H	M	M	M
Watershed Development Ordinance	H	H	H	H	H	H	H
Planning Process							
Conservation Development	H	H	H	H	H	H	H
Floodplain Zoning	H[1]	-	H	M	-	-	-
Impervious Area Reduction	H	H	-	H	H	H	H
Open Space/Natural Greenway	-	-	H	-	-	-	-
Riparian Buffer	M	-	H	M	M	M	M
Site Stormwater BMPs							
Bioswale	H	H	-	H	H	H	H
Filter Strips/Level Spreader	M	M	-	H	H	H	H
Green Roof	H	H	-	-	-	-	-
Naturalized Detention	H	-	M	H	H	H	H
Porous Pavement	H	H	-	H	M	M	H
Rain Barrels/Cistern	-	M	-	-	-	-	-
Rain Garden	M	M	-	-	-	-	-
Vegetated Swale	M	M	-	M	M	M	M
Landscaping							
Native Landscaping	-	H	H	H	H	H	H

[1] Prevents flood damage as a result of high flow rates

"H" = High effectiveness; "M" = Moderate effectiveness; " –" = Not Applicable

Policy/Regulations

Conservation Easement

Definition

Legal mechanism for landowners to place voluntary restrictions on the future use of their land. Generally requires landowner to sell, permanently relinquish, or donate the rights of development.

conservation easements provide mechanism for long term protection of riparian corridors and other sensitive lands

Applicability

➢ Scale	☒ Watershed/ County	☒ Town/Village	☒ Neighborhood	☒ Lot				
➢ Applications	☒ Retrofit	☒ New						
	☐ Roofs	☐ Streets	☐ Driveways					
	☐ Parking Lots	☐ Lawn	☒ Sensitive Areas					
➢ Effectiveness	☐ Runoff Rate Control	☐ Runoff Volume Control	☒ Physical Habitat Preservation/ Creation	☐ Sediment Pollution Control				
	☐ Nutrient Control	☐ BOD Control	☐ Other Pollutant Control					

Benefits

- Preserves significant natural features and open space.
- Protects created/restored natural areas from development and other disturbances.
- Provides opportunity to protect morphologically and ecologically based corridors that may be more difficult to protect with fixed width buffers in many stormwater ordinances.
- Can be used as a tool to create interconnected network of open space (e.g. Green Infrastructure Plan) to improve ecological functioning of overall system.

Design Considerations

- Conservation easements, along with floodplain/open space zoning, ordinance buffer requirements, and conservation design should be used to preserve and create natural resource networks delineated in the Green Infrastructure Plan.
- Conservation easements are best suited to areas not subject to land use change and therefore cannot readily be protected through the development process.
- Conservation easements may also be used to protect high quality uplands and other areas not readily protected through zoning and/or stormwater ordinances.

protected natural areas preserve rural character and improve aesthetics and property values

Policy/Regulations

Stream / Wetland Restoration & Management

Coffee Creek streambank restoration (Chesterton, IN)
(Conservation Design Forum)

Definition

Practices that maintain a healthy ecosystem and/or restore a deteriorated ecosystem to its natural state. In some cases wetlands are used for stormwater treatment. However, it should be recognized that use of wetlands for stormwater treatment will have a significant impact on the floristic diversity of the wetland. For this reason, use of existing wetlands for stormwater treatment is generally discouraged.

Applicability

➢ Scale	☒ Watershed/ County	☒ Town/Village	☒ Neighborhood	☒ Lot	
➢ Applications	☒ Retrofit	☒ New			
	☐ Roofs	☐ Streets	☐ Driveways		
	☐ Parking Lots	☐ Lawn	☒ Sensitive Areas		
➢ Effectiveness	☒ Runoff Rate Control	☒ Runoff Volume Control	☒ Physical Habitat Preservation/ Creation	☒ Sediment Pollution Control	
	☒ Nutrient Control	☒ BOD Control	☒ Other Pollutant Control		

Benefits

- Preserves significant natural features and their habitat, runoff moderation, and water quality benefits.
- Reduces the impact to natural systems from floods and other natural perturbations and improves recovery from these disturbances by preserving natural processes and functions.

Design Considerations

- Conduct a thorough analysis of existing and historic conditions of the restoration site, surrounding area, and watershed to understand system processes and functions.
- Establish stewardship program with local governments, stakeholders, interest groups, and communities to ensure sustained management and monitoring efforts on managed/restored ecosystems.
- Management and stewardship activities should be recognized as ongoing activities. Intensiveness of stewardship activities will decrease as system health and processes are restored.

a successful wetland restoration ensures the healthiness of ecosystems and improves quality of life for both humans and wildlife

Policy/Regulations

Watershed Development Ordinance

Definition

Ordinance to regulate development for the purpose of minimizing on site and off site impacts to flooding and water quality. **Section 4.1** provides recommended regulatory standards.

Watershed development ordinances are designed to preserve and enhance natural site features and protect downstream areas from stormwater impacts

Applicability

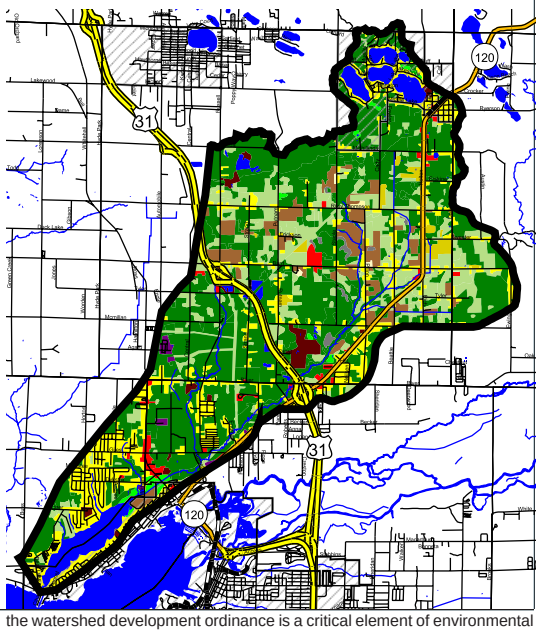
➢ Scale	☒ Watershed/ County	☒ Town/Village	☐ Neighborhood	☐ Lot	
➢ Applications	☒ Retrofit	☒ New			
	☒ Roofs	☒ Streets	☒ Driveways		
	☒ Parking Lots	☒ Lawn	☒ Sensitive Areas		
➢ Effectiveness	☒ Runoff Rate Control	☒ Runoff Volume Control	☒ Physical Habitat Preservation/ Creation	☒ Sediment Pollution Control	
	☒ Nutrient Control	☒ BOD Control	☒ Other Pollutant Control		

Benefits

- Provides consistent level of protection throughout watershed
- Prevents/minimizes degradation of watershed resources
- Establishes orderly rules and procedures for development activities

Design Considerations

- Ordinances should comprehensively address stormwater management, floodplain management, stream and wetland protection, and soil erosion and sediment control.
- Ordinances should include standards to address runoff volumes, runoff rates, and water quality.
- Ordinances should provide flexibility in methods of meeting standards.
- Ordinances should encourage watershed resources restoration activities.



the watershed development ordinance is a critical element of environmental quality control as watershed develops

Planning/Zoning

residential conservation development

Conservation Development

Definition

Site planning and design approach that preserves existing natural areas and utilizes naturalized drainage and detention measures for stormwater management. **Section 3.3** Illustrates application of Conservation Development principals for various land uses.

Applicability

➢ Scale	☒	Watershed/ County	☒	Town/Village	☒	Neighborhood	☐	Lot	
➢ Applications	☐	Retrofit	☒	New					
	☐	Roofs	☒	Streets	☒	Driveways			
	☒	Parking Lots	☒	Lawn	☒	Sensitive Areas			
➢ Effectiveness	☒	Runoff Rate Control	☒	Runoff Volume Control	☒	Physical Habitat Preservation/ Creation	☒	Sediment Pollution Control	
	☒	Nutrient Control	☒	BOD Control	☒	Other Pollutant Control			

Benefits

- Preserves significant natural features and open space.
- Minimizes changes in runoff volumes, rates, and water quality typically associated with urban development.
- Improves views and site aesthetics, while at the same time providing site drainage and water quality functions.

conservation moderate density residential site plan
(Conservation Design Forum)

Design Considerations

- On site natural areas should be identified and preserved.
- Existing natural drainage patterns should be incorporated into site plan.
- Roadway should generally follow ridge lines.
- Impervious runoff should be routed through naturalized drainage systems integrated into the site plan.
- Use of native vegetation adapted to expected hydrologic conditions will improve runoff reduction and water quality benefits
- Naturalized drainage systems should be protected from construction site runoff and sedimentation during establishment.

Planning/Zoning

Floodplain Zoning

Definition

Zoning regulations established to protect stream corridors and floodplains from urban development and other encroachments.

floodplain zoning prevents development from occurring in floodprone areas

Applicability

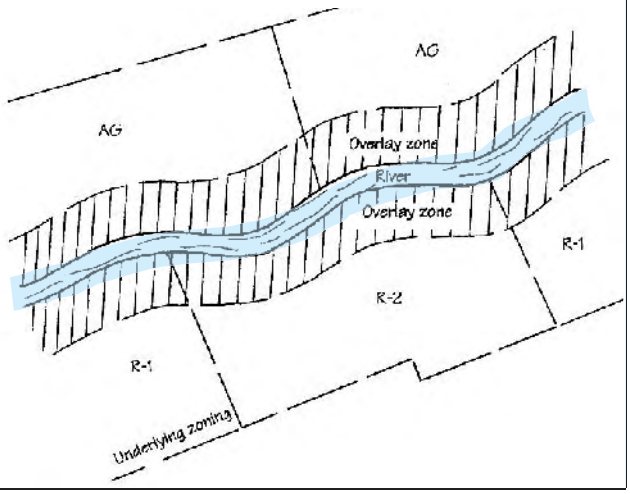
➢	Scale	☒	Watershed/ County	☒	Town/Village	☐	Neighborhood	☐	Lot
➢	Applications	☒	Retrofit	☒	New				
		☐	Roofs	☐	Streets	☐	Driveways		
		☐	Parking Lots	☐	Lawn	☒	Sensitive Areas		
➢	Effectiveness	☒	Runoff Rate Control	☐	Runoff Volume Control	☒	Physical Habitat Preservation/ Creation	☒	Sediment Pollution Control
		☐	Nutrient Control	☐	BOD Control	☐	Other Pollutant Control		

Benefits

- Preserves stream corridors and riparian wetlands and provides natural buffer.
- Enhances safety and quality of life.
- Protects properties from flood damages.
- Protects natural floodplain functions.

Design Considerations

- Zoning regulations should allow for and encourage riparian corridor restoration.



floodplain zoning overlays with underlying zoning (source: SEMCOG)

Planning/Zoning

reduce impervious areas by reducing street width (Seattle, WA)

Impervious Area Reduction

Definition

Impervious area reduction can be achieved by reducing street widths and building setbacks, examining parking lot requirements, and through building design alternatives.

Applicability

➢ Scale	☐ Watershed/ County	☒ Town/Village	☒ Neighborhood	☒ Lot	
➢ Applications	☒ Retrofit	☒ New			
	☒ Roofs	☒ Streets	☒ Driveways		
	☒ Parking Lots	☐ Lawn	☐ Sensitive Areas		
➢ Effectiveness	☒ Runoff Rate Control	☒ Runoff Volume Control	☐ Physical Habitat Preservation/ Creation	☒ Sediment Pollution Control	
	☒ Nutrient Control	☒ BOD Control	☒ Other Pollutant Control		

impervious areas reduced by lessening road length through clustering of development (Conservation Design Forum)

Benefits

- Reduces runoff volumes and rates and associated pollutants.
- Reduces urban heat island effect and thermal impacts to waterbodies.
- Reduces development and maintenance costs.

Design Considerations

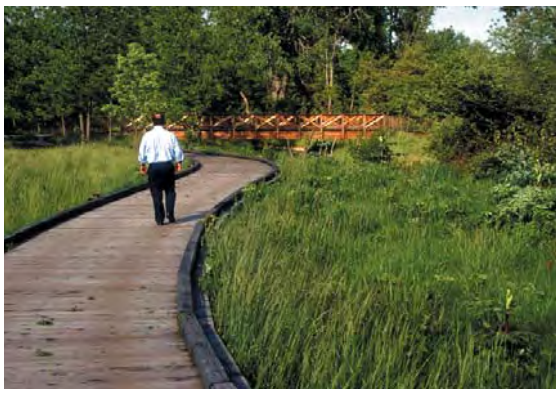
- Impervious area reductions can be achieved through reduced road widths, shared parking, reduced setbacks and other measures. These reductions will often require changes in subdivision code.
- Street length can often be reduced by clustering development onto portions of the site.
- Minimize use of curb and gutter construction that connects impervious surfaces.
- Benefits of impervious area reduction are enhanced when combined with methods to "disconnect" impervious surfaces (using vegetated swales, bioswales, filter strips/level spreaders, etc.).

Planning/Zoning

Open space / Natural Greenway

Definition

Designation of linear open space and/or natural areas as greenways to preserve significant natural features and waterways and to accommodate aesthetic, recreational, and/or transportation uses.



open space greenways can provide recreational as well as habitat and water quality benefits

Applicability

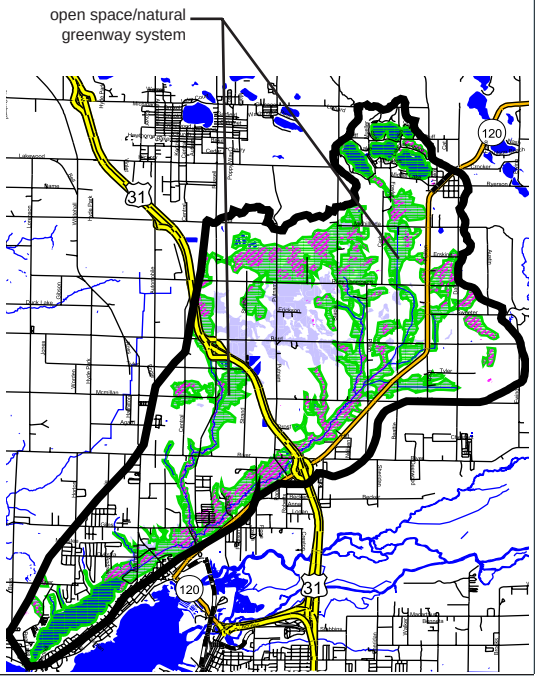
➢ Scale	☒ Watershed/ County	☒ Town/Village	☒ Neighborhood	☐ Lot	
➢ Applications	☒ Retrofit	☒ New			
	☐ Roofs	☐ Streets	☐ Driveways		
	☐ Parking Lots	☐ Lawn	☒ Sensitive Areas		
➢ Effectiveness	☐ Runoff Rate Control	☐ Runoff Volume Control	☒ Physical Habitat Preservation/ Creation	☐ Sediment Pollution Control	
	☐ Nutrient Control	☐ BOD Control	☐ Other Pollutant Control		

Benefits

- Preserves large contiguous natural areas and resources.
- Provides opportunity for wildlife movement and habitat within an ecological network.
- Provides alternative and connected passive recreation and transportation opportunities.

Design Considerations

- A natural resources inventory should be completed to identify significant natural features, including water features, and functioning ecological networks (e.g. Green Infrastructure Plan).
- Significant cultural features should also be integrated into the network.
- Buffer requirements, open space/floodplain zoning, conservation easements, and conservation design should be used together to implement greenway networks.



an open space/natural greenway system (Green Infrastructure Plan) is designated to protect natural resources in the Bear Creek and Bear Lake Watershed area. (Conservation Design Forum)

Planning/Zoning

buffers of native vegetation along streams and wetlands provide natural stabilization and pollutant filtering

Riparian Buffer

Definition

A buffer of native vegetation along lakes, streams, and wetlands that provides water quality and habitat benefits.

Applicability

➢ Scale	☒	Watershed/ County	☒	Town/Village	☒	Neighborhood	☒	Lot
➢ Applications	☒	Retrofit	☒	New				
	☐	Roofs	☐	Streets	☐	Driveways		
	☐	Parking Lots	☒	Lawn	☒	Sensitive Areas		
➢ Effectiveness	☒	Runoff Rate Control	☐	Runoff Volume Control	☒	Physical Habitat Preservation/ Creation	☒	Sediment Pollution Control
	☒	Nutrient Control	☒	BOD Control	☒	Other Pollutant Control		

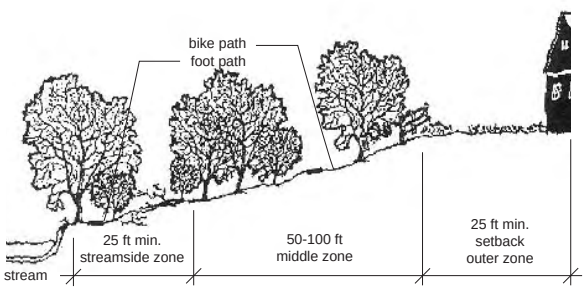
riparian buffers preserve and protect riparian habitat (Little Bear Creek, MI)

Benefits

- Preserves and protects natural functions of lakes, streams, and wetlands.
- Naturally attenuates flow rates.
- Provides water quality filtering of lateral surface and groundwater inflows.
- Helps stabilize streambanks and shorelines against erosion.

Design Considerations

- Riparian buffer width should be dependent on lake, stream, or wetland quality, ground slope, and size of feature.
- Buffer should be planted with native riparian vegetation.
- Buffers are often established/protected through a watershed development ordinance.



a three-zone urban stream buffer system (source: Center for Watershed Protection)

Site Stormwater BMPs

Bioswale

bioswale in a parking lot with curb cuts (Conservation Design Forum)

Definition

Vegetated swale system with an infiltration trench designed to retain and temporarily store runoff, typically from impervious surfaces. Bioswales are planted with native grasses and forbs that enhance filtration, cooling, and cleansing of water in order to improve water quality and prevent sealing of subsoils.

Applicability

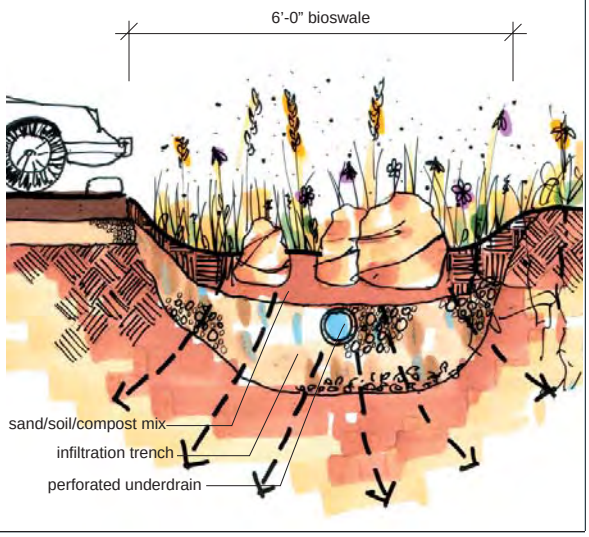
➢ Scale	☐ Watershed/ County	☐ Town/Village	☒ Neighborhood	☒ Lot	
➢ Applications	☒ Retrofit	☒ New			
	☐ Roofs	☒ Streets	☐ Driveways		
	☒ Parking Lots	☐ Lawn	☐ Sensitive Areas		
➢ Effectiveness	☒ Runoff Rate Control	☒ Runoff Volume Control	☐ Physical Habitat Preservation/ Creation	☒ Sediment Pollution Control	
	☒ Nutrient Control	☒ BOD Control	☒ Other Pollutant Control		

Benefits

- Reduces impervious runoff volumes and rates.
- Recharges groundwater and sustains base flows.
- Reduces sediment and nutrient runoff.
- Reduces detention needs when combined with infiltration.

Design Considerations

- Bioswales must be sized and designed to account for drainage area and soils.
- Filtration benefits can be improved by planting native deep-rooted vegetation.
- Infiltration storage should be designed to drain within 24 hours to prevent sealing of subsoils.
- A minimum 12 inch topsoil layer should be provided to protect groundwater quality. The topsoil should have approximately 20% clay, 10% organic material, and 60% sand to provide adequate filtering and infiltration capacity.
- Bioswales should be protected from construction site runoff to prevent sealing of topsoil and/or subsoils.
- Direct entry of stormwater runoff into infiltration trench should be prevented to protect groundwater quality and to prevent sealing of subsoils.
- When necessary, underdrains should be sufficiently low in the trench to provide adequate drainage of aggregate base of adjacent paved areas but sufficiently high to provide infiltration storage.



cross section of a bioswale (Conservation Design Forum)

Site Stormwater BMPs

Coffee Creek Center level spreader installation (Chesterton, IN) (Conservation Design Forum)

Filter Strip/ Level Spreader

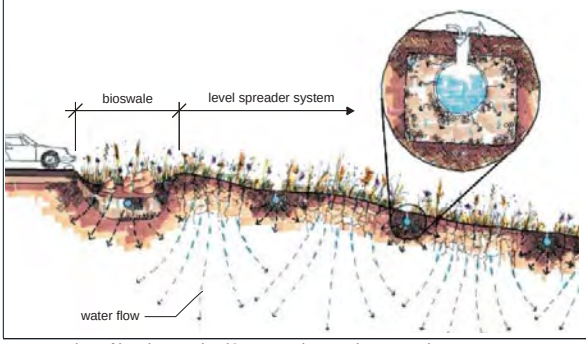
Definition

A **filter strip** is an area with dense, preferably native vegetative cover used to filter and absorb runoff, typically from impervious areas. A **level spreader** is a trench laid on the contour to distribute runoff over filter strip areas.

Applicability

➢ Scale	☐ Watershed/ County	☐ Town/Village	☒ Neighborhood	☒ Lot	
➢ Applications	☒ Retrofit	☒ New			
	☒ Roofs	☐ Streets	☒ Driveways		
	☒ Parking Lots	☒ Lawn	☒ Sensitive Areas		
➢ Effectiveness	☒ Runoff Rate Control	☒ Runoff Volume Control	☐ Physical Habitat Preservation/ Creation	☒ Sediment Pollution Control	
	☒ Nutrient Control	☒ BOD Control	☒ Other Pollutant Control		

filter strips/level spreader



cross section of level spreader (Conservation Design Forum)

Benefits

- Reduces runoff volumes and rates by allowing runoff to infiltrate over a large area.
- Recharges groundwater and sustains base flows.
- Reduces sediment and nutrient runoff.
- Deconcentrates storm sewer and detention basin discharges to dissipate energy, reduce scour, and better mimic historic runoff patterns to receiving waterbody.
- Can reduce detention needs.

Design Considerations

- Filter strips/level spreaders must be sized and designed to account for drainage area, slope and soils. Chronic hydraulic overloading of filter strips may cause erosion.
- Filtration benefits can be improved by planting native deep-rooted vegetation and by minimizing the slope.
- Where untreated stormwater is directly discharged to a level spreader finished in sandy soils, consideration should be given to lining the level spreader trench to prevent contamination of groundwater.
- Compaction of filter strips should be avoided and/or topsoil should be amended with leaf compost to improve filtration, infiltration and plant establishment.
- Runoff should be diverted away from filter strips during construction until vegetation is established.

Site Stormwater BMPs

Green Roof

green roof (Chicago City Hall, IL) (Conservation Design Forum)

Definition

Vegetated roof system designed to retain and slow rainwater runoff on the top of roofs. Green roofs are generally planted with drought and wind tolerant vegetation.

Applicability

➢ Scale	☐ Watershed/ County	☐ Town/Village	☐ Neighborhood	☒ Lot	
➢ Applications	☒ Retrofit	☒ New			
	☒ Roofs	☐ Streets	☐ Driveways		
	☐ Parking Lots	☐ Lawn	☐ Non-Buildable		
➢ Effectiveness	☒ Runoff Rate Control	☒ Runoff Volume Control	☐ Physical Habitat Preservation/ Creation	☐ Sediment Pollution Control	
	☐ Nutrient Control	☐ BOD Control	☐ Other Pollutant Control		

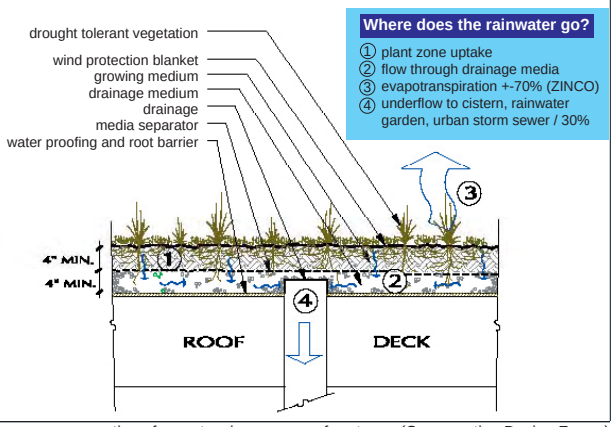
Benefits

- Significantly reduces runoff volumes and rates as well as thermal impacts (50 - 90% reduction in annual runoff).
- Can reduce detention needs.
- Contributes to reduction in urban heat island effect.
- Can reduce energy requirements associated with heating and cooling.
- Creates opportunities for outdoor space as roof top gardens.

green roof can be applied on various roofs and scales (Germany)

Design Considerations

- Structural load capacity of existing roof system must be evaluated.
- Plant material, such as succulents, that are drought tolerant, should be used on lightweight "extensive" green roof systems.
- A wider range of vegetation may be used on heavier, "intensive" green roof systems with deeper growing medium.
- Use of a granular drainage layer will improve retention and detention benefits relative to drain boards.



cross section of an extensive green roof systems (Conservation Design Forum)

Site Stormwater BMPs

Naturalized Detention and Infiltration basins

naturalized wetland detention on Tellabs industrial campus (Conservation Design Forum)

Definition

Naturalized detention basins are used to temporarily store runoff and release it at a rate allowed by ordinances. Infiltration basins temporarily hold water to allow for infiltration. Native wetland and/or prairie vegetation improves water quality and habitat benefits. Naturalized detention and infiltration basins may also be used as a retrofit to achieve water quality and quantity benefits.

Applicability

➢ Scale	☒	Watershed/ County	☒	Town/Village	☒	Neighborhood	☐	Lot	
➢ Applications	☒	Retrofit	☒	New					
	☒	Roofs	☒	Streets	☒	Driveways			
	☒	Parking Lots	☒	Lawn	☒	Sensitive Areas			
➢ Effectiveness	☒	Runoff Rate Control	☐	Runoff Volume Control	☒	Physical Habitat Preservation/ Creation	☒	Sediment Pollution Control	
	☒	Nutrient Control	☒	BOD Control	☒	Other Pollutant Control			

Benefits

- Reduces runoff rates and volumes (infiltration basins).
- Recognized by virtually all stormwater agencies as approved method of controlling stormwater runoff.
- Very effective at removing sediment and associated pollutants.
- Provides attractive site amenity when properly designed and not used as sole BMP on sites with high pollutant/ nutrient runoff.

Design Considerations

- Should be sized to control release to allowable rate.
- For infiltration basins, a minimum 12 inch topsoil layer should be provided to protect groundwater quality. The topsoil should have approximately 20% clay, 10% organic material, and 60% sand to provide adequate filtering and infiltration capacity.
- Infiltration basins should be protected from construction site runoff to prevent sealing of topsoil and/or subsoils.
- Water level fluctuations should be limited to 3-4 feet (during 100-year storm) to maximize plant diversity.
- Shallow water entry slopes (for wet basins) will minimize shoreline erosion, improve water quality benefits, increase aquatic habitat and plant diversity and provide safety ledge.
- May be used as retrofit along stream corridors to prevent direct discharge of stormwater runoff.

a well designed naturalized wet detention pond provides open space and passive recreational opportunities

Site Stormwater BMPs

Porous Pavement

porous pavement driveway

Definition

Permeable or perforated paving materials or pavers with spaces that allow transmission of water to aggregate base and subsoils. Runoff is temporarily stored in the base for infiltration into the subsoils and/or slow release to storm drain system.

Applicability

➢ Scale	☐ Watershed/ County	☐ Town/Village	☒ Neighborhood	☒ Lot	
➢ Applications	☒ Retrofit	☒ New			
	☐ Roofs	☒ Streets	☒ Driveways		
	☒ Parking Lots	☐ Lawn	☐ Sensitive Areas		
➢ Effectiveness	☒ Runoff Rate Control	☒ Runoff Volume Control	☐ Physical Habitat Preservation/ Creation	☒ Sediment Pollution Control	
	☒ Nutrient Control	☒ BOD Control	☒ Other Pollutant Control		

Benefits

- Reduces runoff volumes and rates.
- Recharges groundwater and sustains base flow.
- Filters sediments and associated pollutants from runoff.
- Can reduce detention needs.

porous pavement allows infiltration through the paving material

Design Considerations

- Base and subbase materials should be coarse aggregate with no fines to allow adequate drainage and prevent frost heave.
- Subgrade should be graded at minimum 1% slope to allow drainage when water entry rate exceeds infiltration capacity of subsoils.
- Subsoils should be compacted to the minimum level necessary to achieve structural stability.
- Geotextiles should be used between base and subgrade to improve structural stability and separate base from subgrade.
- Underdrains should be placed at edge of pavement to provide drainage as necessary to prevent ponding in the base for periods greater than 24 hours.
- Permeable paving may not be appropriate for areas sensitive to groundwater contamination and for land uses utilizing or storing hazardous materials.

porous pavement in parking lot

Site Stormwater BMPs

rain barrels in back yard (Conservation Design Forum)

Rain Barrel/ Cistern

Definition

A vessel used to capture and temporarily store rainwater for various uses, including greywater reuse and irrigation.

Applicability

➢ Scale	☐ Watershed/ County	☐ Town/Village	☐ Neighborhood	☒ Lot	
➢ Applications	☒ Retrofit	☒ New			
	☒ Roofs	☐ Streets	☐ Driveways		
	☐ Parking Lots	☐ Lawn	☐ Sensitive Areas		
➢ Effectiveness	☐ Runoff Rate Control	☒ Runoff Volume Control	☐ Physical Habitat Preservation/ Creation	☐ Sediment Pollution Control	
	☐ Nutrient Control	☐ BOD Control	☐ Other Pollutant Control		

Benefits

- Reduces runoff volumes.
- Conserves water for reuse (e.g. irrigation).

a cistern system collects rainwater from Chicago Center for Green Technology (Chicago, IL) (Photo: Conservation Design Forum)

Design Considerations

- At the residential scale, rain barrels located at downspouts will typically be used.
- One inch of rainfall over 1,000 square feet of roof area is equivalent to 625 gallons of rainwater.
- Rain barrels can be used in combination with rainwater gardens, green roofs and other stormwater BMPs to increase stormwater benefits.
- Larger cisterns in some settings may be used to provide greywater for use in toilet flushing and other non-potable uses.

Site Stormwater BMPs

Rain Garden

Definition

A landscaped garden designed to retain and detain stormwater runoff from individual lots and roofs.

rainwater garden planted with vegetation that attracts butterflies while reducing runoff (Maplewood, MN)

Applicability

➢ Scale	☐ Watershed/ County	☐ Town/Village	☐ Neighborhood	☒ Lot	
➢ Applications	☒ Retrofit	☒ New			
	☒ Roofs	☒ Streets	☒ Driveways		
	☐ Parking Lots	☒ Lawn	☐ Sensitive Areas		
➢ Effectiveness	☒ Runoff Rate Control	☒ Runoff Volume Control	☐ Physical Habitat Preservation/ Creation	☐ Sediment Pollution Control	
	☐ Nutrient Control	☐ BOD Control	☐ Other Pollutant Control		

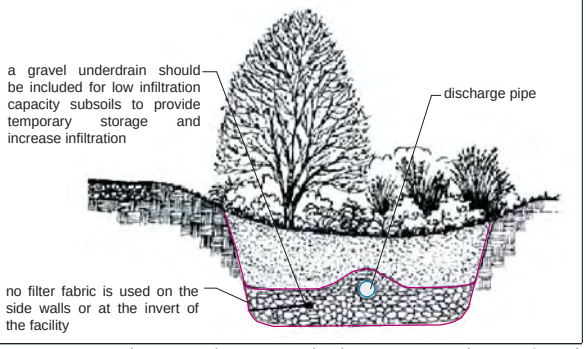
Benefits

- Reduces runoff volumes and rates from lawns, roofs, and driveways.
- Recharges groundwater and sustains base flows.
- Reduces sediment and nutrient runoff.
- Can reduce detention needs.
- Can increase aesthetic value of properties.
- Can provide wildlife habitat.

roof down spout connects to rainwater garden

Design Considerations

- Rainwater gardens must be sized and designed based on drainage area, soils, and desired runoff volume reduction.
- Filtration and nutrient control benefits can be improved by planting native vegetation.
- The soils in the top 12″ to 18″ should be amended with leaf compost to enhance organic content and improve filtration of stormwater runoff.
- Where subsoil infiltration rates are low (less than 0.5 to 1.0 in/hr), a gravel trench with underdrain should be used to encourage drainage between events.
- The rain garden should be designed to drain within 24 hours to maintain aerobic conditions and vegetative health.



rainwater garden cross section (Low Impact Development Center)

Site Stormwater BMPs

vegetated swales planted with native grasses and forbs along the street

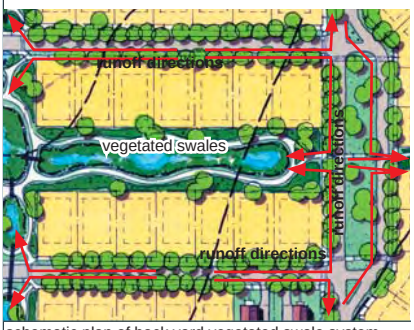
Vegetated Swale

Definition

Vegetated swales are planted stormwater features that convey, retain, infiltrate, and cleanse stormwater.

Applicability

➢ Scale	☐ Watershed/ County	☐ Town/Village	☒ Neighborhood	☒ Lot	
➢ Applications	☒ Retrofit	☒ New			
	☒ Roofs	☒ Streets	☒ Driveways		
	☒ Parking Lots	☒ Lawn	☐ Sensitive Areas		
➢ Effectiveness	☒ Runoff Rate Control	☒ Runoff Volume Control	☐ Physical Habitat Preservation/ Creation	☒ Sediment Pollution Control	
	☒ Nutrient Control	☒ BOD Control	☒ Other Pollutant Control		



schematic plan of back yard vegetated swale system (Conservation Design Forum)

Benefits

- Reduces runoff volumes and rates.
- Provides conveyance and water quality benefits in one stormwater feature.
- Reduces sediment and nutrient runoff.
- With proper design, can reduce detention needs.

Design Considerations

- Vegetated swales must be sized to convey design runoff rate (typically 10-year storm).
- Filtration benefits can be substantially improved by planting native deep-rooted grasses and forbs and by minimizing the slope.
- Topsoil may be amended with compost to improve organic content for filtering and to improve infiltration and retention of runoff.
- Vegetated swales should be protected from construction site runoff to prevent sealing of topsoil and/or subsoils.

back yard vegetated swale

Landscaping

Native Landscaping

prairie planted in residential development area (Mill Creek, IL)

Definition

Establishment of native vegetation in either large restoration projects or smaller gardening projects. Native landscaping is often a component of other BMPs such as detention and infiltration basins, filter strips, bioswales, and rainwater gardens.

Applicability

➢ Scale	☐ Watershed/ County	☐ Town/Village	☒ Neighborhood	☒ Lot	
➢ Applications	☒ Retrofit	☒ New			
	☒ Roofs	☒ Streets	☒ Driveways		
	☒ Parking Lots	☒ Lawn	☒ Sensitive Areas		
➢ Effectiveness	☐ Runoff Rate Control	☒ Runoff Volume Control	☒ Physical Habitat Preservation/ Creation	☒ Sediment Pollution Control	
	☒ Nutrient Control	☒ BOD Control	☒ Other Pollutant Control		

Benefits

- Reduces runoff volumes.
- Increases infiltration rates.
- Increases ability to remove nutrients.
- Increases organic content of soils.
- Increases permeability of compacted soils.
- Reduces irrigation and fertilization requirements.
- Reduces use of fossil fuels and air pollution relative to turf landscapes that require regular mowing and maintenance.
- Provides wildlife habitat.

comparison of root structure between lawn and various native plants in the Illinois and Mid West Region (Conservation Research Institute)

Design Considerations

- Some local "weed" ordinances may need to be amended to allow native and taller vegetation.
- Plant diversity and health is maximized by annual burning. Plots may be mowed and then burned to prevent spread of fire on small sites. Fall burning will select for prairie wildflowers.
- On compacted soils, amendment may be necessary to increase organic content, improving success of establishment.

Blackwell Prairie, IL

3.3 Conservation Design Templates

This section provides site scale "Templates" that demonstrate application of the stormwater BMPs and techniques described in **Section 3.2** within different land use types.

The templates are generally 40-acre sites and are designed to illustrate conservation-based development and land management techniques and to contrast those techniques to more typical conventional development. The concepts illustrated in these templates are transferable to most development plans.

The terms "conservation" and "conventional" are used throughout this section in reference to the various site planning and stormwater techniques utilized on development projects. "Conservation" refers to techniques and BMPs that are based on ecologically sensitive design and planning principles. Conservation templates combine various sustainable design concepts with such names as "green design", "low-impact development", "sustainable development", "ecological design", "smart growth", and others. Conservation development uses site planning techniques to protect on site sensitive areas and distributed stormwater management techniques that integrate runoff management throughout the site plan. These strategies are designed to integrate stormwater, habitat, livability, restoration, and other ecological goals to achieve overall superior site plans.

"Conventional" is the second design descriptor used in this section, and refers to practices that are typically being utilized in land development and building construction today in the Midwest. Even though conservation and conventional designs are both allowed by code, conventional designs and techniques are seen most often, and thus represent the default designs and practices for a majority of communities and developments. Conventional developments rarely consider ecological health and the other goals of this project, beyond the minimum necessary to meet regulatory requirements.

The templates are provided to help guide local authorities, land owners, and designers in implementing the stormwater BMPs of **Section 3.2**. The seven templates discussed in this section are:

- Commercial/Industrial
- Moderate Density Development
- Rural Residential
- Estate Residential
- Agriculture
- Stream Corridors
- Depressional Wetlands

The relative cost of conservation development vs conventional is highly dependent on the specifics of the development site and the design characteristics of the plan. However, studies indicate that the cost of conservation development can be less than conventional at several levels. A cost comparison of the templates presented in this section shows that the conservation versions of the commercial and residential templates have lower expected construction costs relative to the conventional versions.[1] A study on the municipal fiscal impact of conservation design indicates that conservation development should generally have a greater positive impact on revenues vs costs at the municipal level than conventional development.[2] Finally, another study indicates that conservation development that increases retention of stormwater runoff should have a positive impact on the economy due to reduced flooding and improved water quality as well as reduced infrastructure cost and increased aquifer recharge.[3]

[1] *Changing Cost Perceptions: An Analysis of Conservation Development*, Conservation Research Institute, 2004
[2] *Alternative Futures Fiscal Study, Blackberry Creek Watershed, Kane County, Illinois*, Center for Governmental Studies, Northern Illinois University, 2004
[3] *The Downstream Economic Benefits of Stormwater Retention*, Department of Agriculture and Consumer Economics, University of Illinois, 2003

Template Methodology and Design Exercise

For each land use or ecosystem template, two versions are provided; 1) a conventional template using current default or standard-of-practice site design and planning techniques, and 2) a conservation template, which uses environmental design principles and integrated best management practices for stormwater management. Both templates in each land use category have been designed with identical numbers of units, commercial square footage, etc., but are arranged and organized in different ways over the site, and use different stormwater management and landscaping techniques.

Although the site planning and stormwater management concepts illustrated in the conservation templates can be applied to development sites, the templates should not be viewed as "stencils" to be "stamped" across the watershed. A significant element of conservation design is adapting the site and stormwater plan to the specific conditions of the site.

Template Design Principles

General environmental design principles are incorporated into the example urban conservation templates to protect and/or enhance stormwater quality.

1. Development avoids natural features to the extent possible, including: streams, wetlands, remnant natural areas, and critical habitats.
2. Water features are protected, buffered, linked, and enhanced/restored where possible.
3. The site plan respects site topography, utilizing natural drainage patterns to minimize the need for built infrastructure.
4. Clustering of built areas, a range of lot sizes, and other design techniques are used to create views, privacy, and amenities for each home site. This facilitates protection of site natural areas, integration of naturalized stormwater management systems, and linked habitat areas, while also leading to efficient utilization of site topography and provisions for common open space
5. Created native landscapes are integrated as part of the stormwater management system to utilize their natural filtration, infiltration, storage, and transpiration processes as well as their habitat and aesthetic benefits.
6. Where appropriate, engineered systems based on natural processes are utilized as part of the stormwater management system for the purpose of enhancing groundwater recharge, stabilizing site and regional hydrology, and minimizing irrigation needs.
7. Stormwater is managed as close to its source as feasible to take advantage of the areas permeable soils to emulate existing conditions.
8. Conservation site planning and design techniques used in the templates are generally cost-effective and have been used and proven in existing developments in the Midwest.

The focus of these principles is on protection of aquatic habitat from the direct and indirect impacts of development and prevention of flooding and streambank erosion. However, it should be noted that there are many other "green" design and planning principles (i.e., energy conservation) that are not directly addressed as part of this project as their link to watershed protection is less direct.

Conservation Design Templates

Conventional Commercial/Industrial Template

Commercial/Industrial

General Character

Commercial/industrial developments include retail, light industrial and offices in various scales from large scale "big box" retail stores and light industrial and office park development, to smaller scale restaurants, shops, and individual offices.

➢ Conventional Template

The Conventional Template is laid out as a typical strip mall, with two "big box" retail establishments, isolated outlet shops, and parking, landscaping and stormwater detention according to code.

➢ Conservation Template

Like the Conventional template, the Conservation Template has two "big box" retail stores, but in the conservation design, they have green roofs and are designed as part of a "Main Street" retail setting with second floor mixed-use areas, a plaza and parking both on-street and in parking lots. Permeable paving systems are used in the parking lots along with stormwater infiltration bioswales as part of a naturalized and landscaped stormwater system.

BMPs Applied in the Conservation Template

➢ Policy/Regulations
- ☐ Conservation Easement
- ☐ Stream/Wetland Management and Restoration
- ☒ Watershed Development Ordinance

➢ Planning/Zoning
- ☒ Conservation Development
- ☐ Floodplain Zoning
- ☒ Impervious Area Reduction
- ☐ Open Space/Natural Greenway
- ☐ Riparian Buffer

➢ Site Stormwater BMPs
- ☒ Bioswales
- ☐ Filter Strips/Level Spreaders
- ☒ Green Roofs
- ☒ Naturalized Detention
- ☒ Porous Pavement
- ☐ Rain Barrels/Cisterns
- ☒ Rain Gardens
- ☒ Vegetated Swales

➢ Landscaping
- ☒ Native Landscaping

Conservation Commercial/Industrial Template

Conservation Design Templates

Moderate Density Residential

General Character

Moderate density residential development is defined for this project as having a gross density of approximately 2 units per acre with lot sizes ranging from 6,000 to 15,000 square feet with municipal water and sewer service. Typically, these developments are under municipal jurisdiction, but may occur in unincorporated areas as part of planned unit developments (PUD's).

Conventional Moderate Density Residential Template

➢ Conservation Template

The Conservation Template includes narrower streets and an integrated, naturalized stormwater system that hosts trails and public open space and allows every residence to back to open space.

➢ Conventional Template

The Conventional Template includes wide roads, no public open space, and storm sewers discharging into turf and/or rip-rap lined detention basins.

BMPs Applied in the Conservation Template

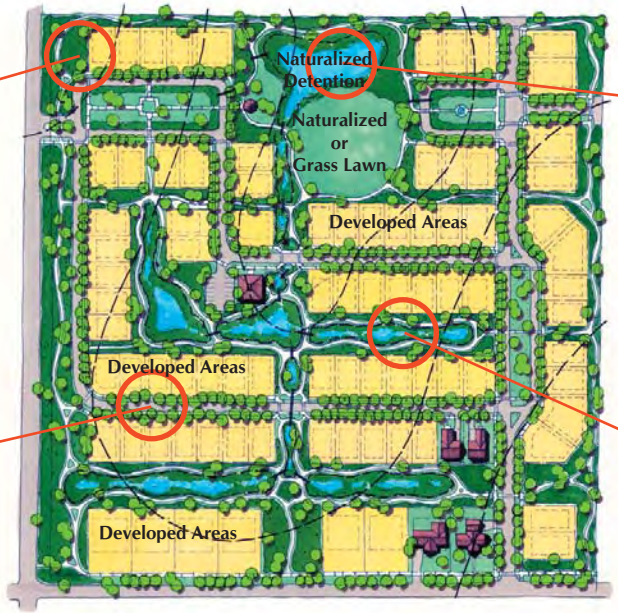
➢ Policy/Regulations
- ☐ Conservation Easement
- ☐ Stream/Wetland Management and Restoration
- ☒ Watershed Development Ordinance

➢ Planning/Zoning
- ☒ Conservation Development
- ☐ Floodplain Zoning
- ☒ Impervious Area Reduction
- ☐ Open Space/Natural Greenway
- ☐ Riparian Buffer

➢ Site Stormwater BMPs
- ☒ Bioswales
- ☐ Filter Strips/Level Spreaders
- ☐ Green Roofs
- ☒ Naturalized Detention
- ☐ Porous Pavement
- ☒ Rain Barrels/Cisterns
- ☒ Rain Gardens
- ☒ Vegetated Swales

➢ Landscaping
- ☒ Native Landscaping

Native Landscaping



Naturalized Detention

Bioswale

Vegetated Swale/ Rain Garden

Conservation Moderate Density Residential Template

Conservation Design Templates

Conventional Rural Residential Template

Rural Residential

General Character

The Rural Residential Template is defined as having lots averaging approximately 1.25 acres, a gross density of 0.55 units per acre, served by private wells and septic systems. Typically, rural residential development is limited to unincorporated areas. However, more recently, many developments of this density have come under municipal jurisdiction, and would then often be served by municipal water and sewer.

➢ Conventional Template

The Conventional Template includes a cul-de-sac drained with storm sewers discharging into detention basins.

➢ Conservation Template

The Conservation Template includes a narrow lane and a naturalized stormwater system that utilizes the landscape to filter, evapotranspire, and absorb runoff as well as hosting walking/ biking trails.

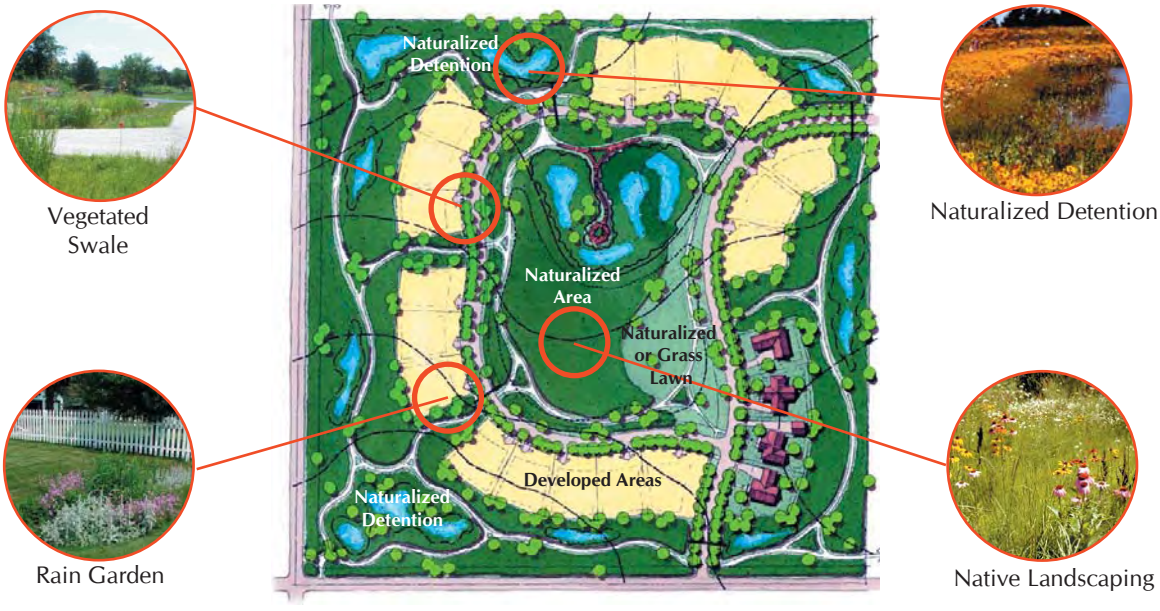
BMPs Applied in the Conservation Template

➢ Policy/Regulations
- ☒ Conservation Easement
- ☐ Stream/Wetland Management and Restoration
- ☒ Watershed Development Ordinance

➢ Planning/Zoning
- ☒ Conservation Development
- ☐ Floodplain Zoning
- ☒ Impervious Area Reduction
- ☐ Open Space/Natural Greenway
- ☐ Riparian Buffer

➢ Site Stormwater BMPs
- ☒ Bioswales
- ☐ Filter Strips/Level Spreaders
- ☐ Green Roofs
- ☒ Naturalized Detention
- ☐ Porous Pavement
- ☒ Rain Barrels/Cisterns
- ☒ Rain Gardens
- ☒ Vegetated Swales

➢ Landscaping
- ☒ Native Landscaping



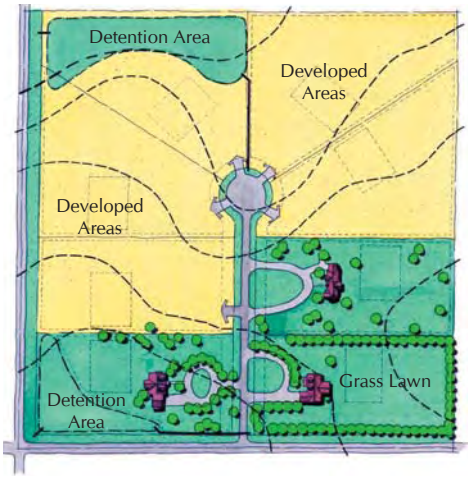
Conservation Rural Residential Template

Conservation Design Templates

Estate Residential

General Character

Estate residential development is defined as having lots averaging approximately 2.5 acres in size, a gross density of approximately 0.2 units per acre, served by private well and septic systems. Estate residential developments occur almost exclusively in unincorporated areas.



Conventional Estate Residential Template

➢ Conservation Template

The Conservation Template has shorter driveways and uses native plantings and a conservation easement. The Conservation Template disturbs the minimum amount of land necessary to install the roads, houses, and septic systems. The remainder is undisturbed or is restored.

➢ Conventional Template

The Conventional Template has longer driveways and is primarily landscaped with lawn.

BMPs Applied in the Conservation Template

➢ Policy/Regulations
- ☒ Conservation Easement
- ☐ Stream/Wetland Management and Restoration
- ☒ Watershed Development Ordinance

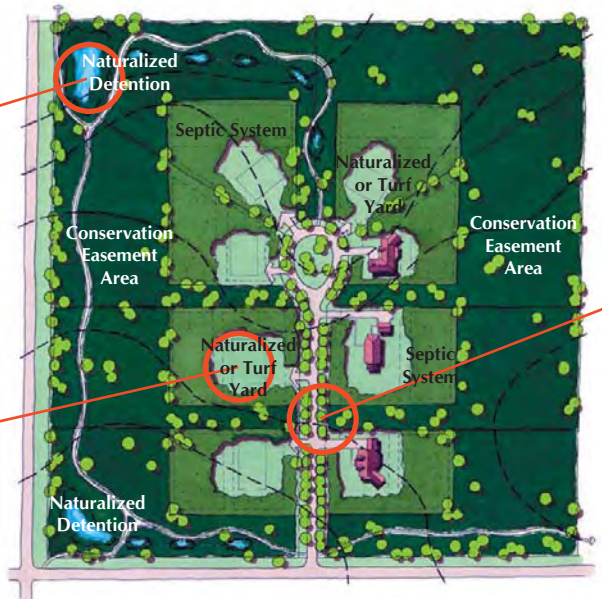
➢ Planning/Zoning
- ☒ Conservation Development
- ☒ Floodplain Zoning
- ☐ Impervious Area Reduction
- ☒ Open Space/Natural Greenway
- ☒ Riparian Buffer

➢ Site Stormwater BMPs
- ☒ Bioswales
- ☐ Filter Strips/Level Spreaders
- ☐ Green Roofs
- ☒ Naturalized Detention
- ☐ Porous Pavement
- ☒ Rain Barrels/Cisterns
- ☐ Rain Gardens
- ☒ Vegetated Swales

➢ Landscaping
- ☒ Native Landscaping

Naturalized Detention

Native Landscaping

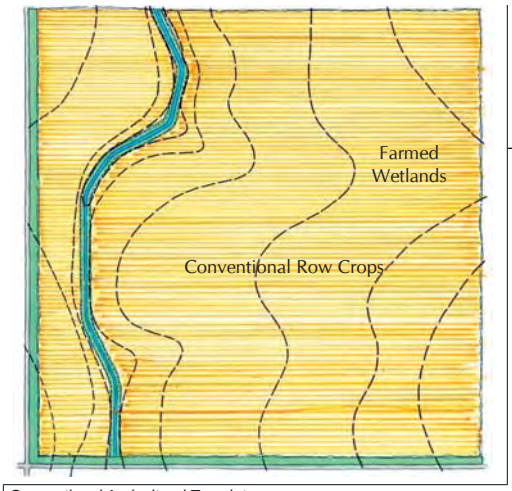


Vegetated Swales

Conservation Estate Residential Template

Conservation Design Templates

Agricultural



Conventional Agricultural Template

General Character

Agricultural lands are cultivated and manipulated for the production of food crops and/or livestock for sale beyond the immediate use of the farmer or landowner.

➢ Conventional Template

The Conventional Template is typical row-crop agriculture, that includes the use of herbicides, pesticides, tillage of the soil, and mono-crop production.

➢ Conservation Template

The Conservation Template includes a variety of techniques and environmentally sound agricultural practices that can improve the hydrology and water quality of the watershed. Those practices include contour plowing, native seed production, reduced or no-till techniques, organic farming, biodynamic or permaculture techniques, animal grazing on native grassland, and buffer zones.

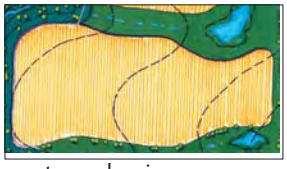
BMPs Applied in the Conservation Template

➢ Policy/Regulations
- ☒ Conservation Easement
- ☒ Stream/Wetland Management and Restoration
- ☐ Watershed Development Ordinance

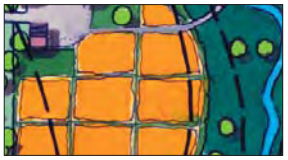
➢ Planning/Zoning
- ☐ Conservation Development
- ☐ Floodplain Zoning
- ☐ Impervious Area Reduction
- ☒ Open Space/Natural Greenway
- ☒ Riparian Buffer

➢ Site Stormwater BMPs
- ☐ Bioswales
- ☒ Filter Strips/Level Spreaders
- ☐ Green Roofs
- ☐ Naturalized Detention
- ☐ Porous Pavement
- ☐ Rain Barrels/Cisterns
- ☐ Rain Gardens
- ☒ Vegetated Swales

➢ Landscaping
- ☒ Native Landscaping

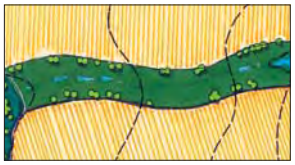

contour plowing, perennial crops, or grazing

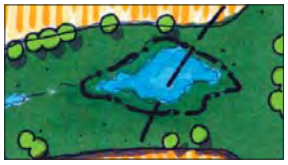

re-meandered stream


non-row crops


sustainable woodlot


floodplain buffer


conservation connector


restored wetlands

Conservation Agricultural Template

Conservation Design Templates

Stream Corridor

General Character

Stream corridors are linear spaces along streams, creeks and rivers.

➢ Conservation Template

The Conservation Template depicts a healthy stream corridor with the freedom to meander naturally and includes wetlands and floodplains adjacent to the stream. The developed areas represent lands that may be agricultural or urban land uses. Those developed areas in the conservation version will have little impact on the stream provided that the management practices outlined in the conservation versions of the urban and agricultural templates are used. Level spreaders and filter strips should be used dissipate the energy of concentrated stormwater runoff and eliminate point discharges.

Conventional Stream Corridor Template

➢ Conventional Template

The Conventional Template represents a degraded stream corridor, which has been channelized and often includes no natural buffer.

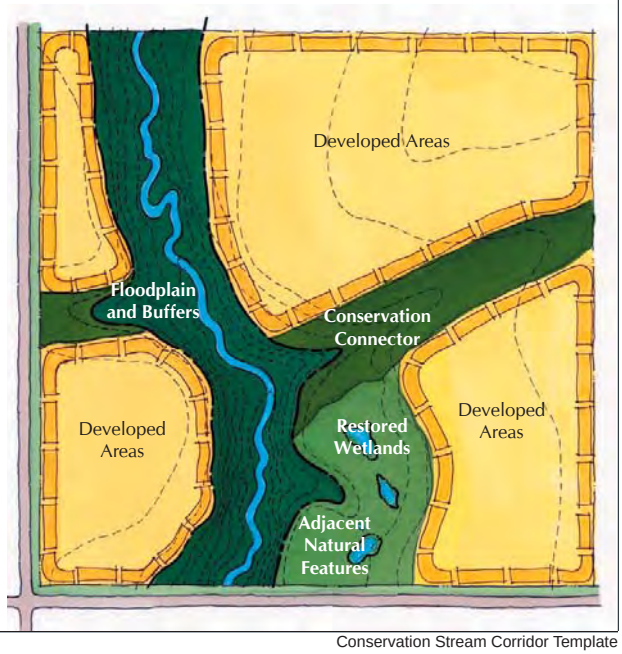
BMPs Applied in the Conservation Template

➢ Policy/Regulations
- ☒ Conservation Easement
- ☒ Stream/Wetland Management and Restoration
- ☒ Watershed Development Ordinance

➢ Planning/Zoning
- ☒ Conservation Development
- ☒ Floodplain Zoning
- ☐ Impervious Area Reduction
- ☒ Open Space/Natural Greenway
- ☒ Riparian Buffer

➢ Site Stormwater BMPs
- ☐ Bioswales
- ☒ Filter Strips/Level Spreaders
- ☐ Green Roofs
- ☐ Naturalized Detention
- ☐ Porous Pavement
- ☐ Rain Barrels/Cisterns
- ☐ Rain Gardens
- ☐ Vegetated Swales

➢ Landscaping
- ☒ Native Landscaping



Conservation Stream Corridor Template

Conservation Design Templates

Depressional Wetlands

Conventional Depressional Wetlands Template

General Character

Depressional wetlands are landscape features generally distinct from flowing streams and have vegetation, hydrology and soils characteristics of wet conditions. Historically, depressional wetlands were located where the ground dropped below the water table and therefore served as discharge zones or flow-through zones. The areas in yellow represent developed areas for agricultural or urban land uses.

➢ Conventional Template

In the Conventional Template, the hydrology has been manipulated through agricultural or urban development, many of these wetlands now receive a much greater amount of surface runoff and a reduction in groundwater discharge.

➢ Conservation Template

In the Conservation Template, the developed areas utilize the practices outlined in the conservation versions of the other described templates. Those developed areas in the conservation version will have little impact on the stream provided that the management practices outlined in the conservation versions of the urban and agricultural templates are used. Level spreaders and filter strips should be used dissipate the energy of concentrated stormwater runoff and eliminate point discharges.

BMPs Applied in the Conservation Template

➢ Policy/Regulations

- ☒ Conservation Easement
- ☒ Stream/Wetland Management and Restoration
- ☒ Watershed Development Ordinance

➢ Planning/Zoning

- ☒ Conservation Development
- ☒ Floodplain Zoning
- ☐ Impervious Area Reduction
- ☒ Open Space/Natural Greenway
- ☒ Riparian Buffer

➢ Site Stormwater BMPs

- ☐ Bioswales
- ☒ Filter Strips/Level Spreaders
- ☐ Green Roofs
- ☐ Naturalized Detention
- ☐ Porous Pavement
- ☐ Rain Barrels/Cisterns
- ☐ Rain Gardens
- ☐ Vegetated Swales

➢ Landscaping

- ☒ Native Landscaping

Conservation Depressional Wetlands Template

The recommendations presented in this chapter are intended to address stormwater management issues of the Bear Creek and Bear Lake Watershed as described in the site inventory and data analysis of **Chapter II**, The recommendations also utilize the stormwater management strategies summarized in **Chapter III**.

Watershed stormwater management recommendations are divided into three sections:
Section 4.1 discusses the Michigan DEQ Hydrologic Study and identifies recommendations for release rates based on that study.

Section 4.2 provides recommended regulatory standards for stormwater related ordinances and regulations that should be implemented throughout the Bear Creek and Bear Lake Watershed.

Section 4.3 provides more geographically specific stormwater management recommendations based on the conditions specific to five watershed management units. The watershed management units were delineated based on physiographic conditions such as proximity to stream and wetland resources, depth to groundwater and hydric soil conditions, and presence of existing development.

4.1 Michigan DEQ Hydrologic Study

The *Hydrologic Study of the Bear Creek and Bear Lake Watershed* (MDEQ, 2003) showed significant increases in flow rates under build-out conditions in a number of locations in the watershed and three areas where the flow rates would exceed the ordinance specified 25-year release rate in Kent County and also being considered in other townships. It is noteworthy that two of the three locations in the watershed are on the mainstem whose flow rates are influenced by runoff from most of the watershed. It is also noteworthy that there are significant areas of the watershed that were identified as being "non-contributing" of surface runoff under both existing and build out conditions. Finally, Little Bear Creek and the mainstem below McMillan Road currently have discharge rates less than 0.008 cfs/acre for the 2-year event, which was found to be the threshold flow rate for an unimpaired fishery in a nearby watershed. However, under build-out conditions, essentially no areas would be below the fishery threshold discharge rate. All of the indicated increases assume that there will be no changes in development practices or ordinances to require detention and other stormwater management measures. **The analysis clearly shows that steps must be taken to prevent increases in flow rates that would lead to increases in flooding, streambank erosion, and loss of the potential to support a trout fishery.**

Most areas of the watershed currently contribute less than 0.01 cfs/acre for the 2-year event and 0.10 cfs/acre for the 25-year event. Further, the watershed may be on the threshold of being able to support a trout fishery as discussed above. This suggests that the release rates being used in nearby townships based on the Kent County model (0.05 cfs/acre for the 2-year event and 0.13 cfs/acre for the 25-year event) may not be sufficient to prevent increases in streambank erosion and expansion of the floodplain in most areas of the watershed.

Based on the above, it is recommended that 2-year and 25-year release rates less than the Kent County values be applied to the Bear Creek and Bear Lake Watershed. Further study would be required to determine the exact release rates required to prevent increases in flow rates

throughout the watershed. However, in the absence of such a study, it is recommended that the 1997 discharge rates be maintained and that measures to control increases in runoff volumes be required. Release rate and runoff volume recommendations are discussed further under the Regulatory Recommendations of **Section 4.2**.

4.2 Stormwater Regulatory Recommendations

In a developing watershed, a critical component of watershed protection is comprehensive stormwater management standards that address stormwater runoff, floodplain management, stream and wetland protection, and soil erosion and sediment control.

Previous sections of this plan provided guidelines on stormwater management and site design strategies to minimize stormwater impacts and protect watershed resources. However, without adequate regulatory standards and incentives, these measures may not be implemented. This section is intended to provide the regulatory standards necessary to require implementation of the stormwater BMPs of **Section 3.2**, as well as other strategies to protect watershed resources.

The recommended ordinance standards are intended to apply to new development and substantial redevelopment. The standards should also be applied to private development activities as well as public projects (including roads, utilities, schools, and park facilities). Finally, the ordinance standards should apply to both incorporated and unincorporated areas of the watershed.

In addition to developing an ordinances, design guidance and technical education are critical components to efficient application of the ordinance standards. Design guidance should take the form of a Stormwater Manual that provides guidance to engineers, planners, and landscape architects on analysis and design methods necessary to meet the ordinance standards. Courses on design, implementation, and maintenance of stormwater facilities is also recommended.

While a comprehensive stormwater ordinance is a critical element of watershed protection, it should be understood that a regulatory program alone is not sufficient to protect and improve the watershed. The policy/regulation and planning/zoning tools described in **Section 3.2** and the zone specific recommendations of **Section 4.3** should also be implemented along with the recommendations of the Bear Creek and Bear Lake Watershed Management Plan.

The following are recommended components of a stormwater ordinance and regulatory standards.

Comprehensive Purpose Statements

The stormwater ordinances should include a comprehensive statement of purpose addressing the following objectives for the Bear Creek and Bear Lake Watershed.

- Protect and preserve the quality and environmental values of land and water resources in the Watershed.
- Protect and preserve the health and safety of residents of the Watershed.
- Encourage development in a manner that promotes orderly, sustainable, and cost-effective utilization of land and water resources consistent with regional plans.
- Ensure that new development in the Watershed does not cause increases in flood damages, water quality degradation, and habitat loss.
- Prevent increases in economic disruption due to flooding and drainage problems.
- Protect and improve the natural hydrologic, water quality, aquatic habitat, recreational, and aesthetic functions of streams, lakes, wetlands, and floodplains.
- Address the goals of the Bear Creek/Lake Watershed Management Plan.

Stormwater Management

Ordinance Applicability: Ordinance standards should apply to all development, regardless of size. However, as a practical matter, the requirement that a permit be obtained may be limited to developments over a specified size. (e.g., greater than one unit of residential or more than 0.5 acres of impervious for non-residential)

Control the Release Rate for the Channel Forming Event: The discharge rate from development sites should be sufficiently low to prevent increases in instream flow rates during channel-forming (bankfull) events. A release rate for the channel-forming event should be specified to prevent increases in streambank erosion which is typically the result of increases in the magnitude of 2-year and smaller runoff events. To prevent increases in streambank erosion and to continue hydrologic conditions supportive of a trout fishery, the allowable 2-year release rate for all new development should not exceed 0.008 cfs/acre or the 1997 subarea flow rates of the Michigan DEQ study, whichever is less.

Control the Release Rate for Flood Causing Events: The discharge rate for flood causing events should be limited to prevent increases in instream flow rates and enlargement of floodplains as the watershed develops. Based on the results of the MDEQ Hydrologic Study, the allowable 25-year release rate should not exceed 0.10 cfs/acre or the 1997 subarea flow rates of the Michigan DEQ study, whichever is less. Further modeling should be performed to verify that control of the 25-year event is sufficient to prevent increases in 100-year discharge rates and, therefore, prevent expansion of the regulatory floodplain as the watershed develops.

Establish Overland Flow Routes: Overland flow routes should be identified within developments and placed in easements to ensure that runoff events in excess of the design event are able to be accommodated with minimal damage to property. For example, detention basins should be designed with reinforced overflow structures and a route for the excess flow should be established. This will minimize the potential for flooding of buildings surrounding detention facilities by allowing excess runoff out of the basin and buildings downstream of detention facilities by preventing embankment failure due to overtopping.

Consider Downstream Drainage Conditions: Site discharge rates should consider the condition of drainageways downstream from the site. For example, there may be locations where there is insufficient capacity for even the allowable release rates identified previously. Further, there are areas of the watershed that were found to be "non-contributing in the MDEQ hydrologic study. This condition should be maintained as the watershed develops.

Limit Increases in Runoff Volumes: Due to the relatively permeable soils of the Bear Creek and Bear Lake Watershed, hydrology of the watershed is largely groundwater driven. Significant increases in surface runoff will have a significant impact on flooding, streambank erosion, and the ecology of streams and wetlands in the watershed as well as Bear Lake. It should be recognized that detention is very effective in preventing increases in runoff rates but does not prevent increases in runoff volumes and therefore detention alone will not address this issue.

Infiltration-based site stormwater BMPs, including those identified in **Section 3.2**, should be utilized to minimize increases in runoff volumes from development sites. A number of states, including Maryland, allow no increase in runoff volumes. The Northeastern Illinois Planning Commission model Conservation Design Ordinance also recommends no increase in runoff volumes. New rules in the State of Wisconsin require that 90% and 60% of the pre-development infiltration volume be maintained for residential and non-residential projects, respectively.

The standard recommended for the Bear Creek and Bear Lake Watershed is no more than a 10% increase in runoff volumes for residential projects and no more than a 30% increase in runoff volumes for non-residential projects for the 2-year event.

Preserve On Site Depressional Storage: Existing on-site depressional storage should be preserved independently of required detention and runoff volume controls. Even with no change in land cover, significant increases in flood volumes and rates will be experienced if watershed depressional storage is lost.

Minimize Discharge of Stormwater Pollutants: Runoff from urban development is contaminated with a number of pollutants including sediment, heavy metals, oil and grease, bacteria, and nutrients. Water quality BMPs such as bioswales, rain gardens, filter strips, infiltration basins, constructed wetlands, and naturalized wetland detention should be incorporated into stormwater management systems to treat stormwater runoff. Design guidelines for these BMPs are provided in **Section 3.2**. Pollutants should be addressed on site to protect downstream lakes, streams, and wetlands.

Potential groundwater contamination is a significant issue due to the existence of sandy soils and two superfund sites (Ott/Story/Cordova and Duell/Gardener) within the Bear Creek and Bear Lake Watershed. To prevent groundwater contamination, special precautions should be taken to prevent rainfall from coming into contact with hazardous materials during storage, handling, and processing activities. Stored materials such as road salt, compost, fertilizers should also be protected from rainfall and washoff.

Infiltration based stormwater practices should include pre-treatment measures to protect against groundwater contamination from pollutants generally present in stormwater. In most cases, a minimum topsoil thickness of 12 inches should be sufficient to provide treatment prior to infiltration into the sandy subsoils. The topsoils should contain sufficient clay and organic content (20% clay and 10% organic content) to remove nutrients, metals, and petroleum-based hydrocarbons present in typical stormwater runoff. These features will not be sufficient to protect against spills, and other inappropriate handling of hazardous materials.

Wet and wetland detention basins have been shown to be much more effective than dry bottom basins in achieving stormwater pollutant removal unless those dry basins also serve as infiltration basins. Wet basins landscaped with native wetland and prairie vegetation have been found to be particularly effective at removing pollutants and preventing inbasin shoreline erosion. Infiltration basins should be designed with an adequate topsoil layer as described above and in **Section 3.2**.

For new developments, stormwater BMP's should be designed to remove 80% of the average annual Total Suspended solids (TSS) load (for post-development conditions). Removal rate should be based on a weighted average of the TSS removal rates for the various BMPs used on the site.

Detention and other BMPs Should be Designed Using Appropriate Hydrologic Methods: Detention basins and swales should be designed using hydrograph routing techniques and using the most current rainfall data. Currently, the most up-to-date design precipitation data is from Rainfall Frequency Atlas of the Midwest, Bulletin 71 (Huff 1992), using the Mean Frequency Data for Michigan, Section 08. In a study of hydrologic design methods conducted by the Northeastern Illinois Planning Commission, it was found that non-hydrograph based techniques (e.g., the modified rational formula) significantly underestimate detention requirements (Price and Dreher, 1991). It was also found in the NIPC study that detention volumes will be significantly undersized using Technical Paper 40 (Hershfield, 1961) precipitation data.

Require Operation and Maintenance Plans for New Stormwater Management Facilities: For stormwater infrastructure to function properly it must be maintained in its design condition. Maintenance agreements and easements as well as special service areas are among the methods that can be used to assure maintenance.

Prohibit Connection of Stormwater Drainage Systems to Agricultural Tile Systems: Agricultural tile systems were designed to drain groundwater under free flow conditions and were not constructed for maintenance access. Also, many of the tiles were installed up to several decades ago and were constructed of lower-strength materials than modern storm sewers. Surcharging of drain tiles as a result of discharge of surface stormwater runoff can rupture these tiles that are difficult to maintain and repair and do not have easements associated with them to allow maintenance access.

Floodplain, Stream, and Wetland Protection

For the purposes of these standards, the term "stream" applies to both stream and drain reaches of Bear Creek.

Compensate for Lost Storage in the Floodplain and Depressional Storage Areas: To prevent increases in flood flows and stages, hydraulically equivalent compensatory storage should be required for all fill activities in the floodplain and depressional storage areas. As a safety factor, compensatory storage should be provided at a conservative ratio greater than 1:1.

Discourage Detention in the Flood Fringe: Detention in the floodplain is difficult to design to function properly under all flood stage conditions. When detention must be placed in the flood fringe, compensatory storage should be provided for the entire floodplain volume displaced by the detention basin.

Prohibit Detention in the Floodway: Detention should not be placed in the floodway due to concerns over proper functioning under flood stage conditions, potential obstruction of flood flows, reduction in conveyance capacity of the floodway, and potential flushing of pollutants captured by the detention basin during previous flood events.

Prohibit Onstream Detention: Onstream detention should be prohibited unless it provides regional flood control benefits, is in the public interest, and environmental mitigation is provided. Unless onstream detention is accompanied by on site BMPs designed for stormwater pollutant removal, the stream will act as a sink for runoff pollutants, which is inconsistent with watershed objectives and the requirements of the federal Clean Water Act. This standard will avoid the high maintenance costs often associated with dredging of on-stream facilities as well as prevent degradation of stream resources.

Prohibit Direct Discharge of Stormwater Runoff to Wetlands, Streams, and Lakes: Wetlands have the ability to provide significant pollutant filtering benefits. However, natural wetlands that are called upon to mitigate stormwater impacts, will experience significant degradation in biodiversity and habitat. Thus, stormwater runoff should be pre-treated with stormwater BMPs prior to discharge to natural and mitigation wetlands. The site stormwater BMPs identified in **Section 3.2** should provide adequate pre-treatment. Stormwater released from detention and other pre-treatment measures should drain to a stream, lake, or wetland buffer and not directly to the feature itself. Level spreaders and broad swales should be used to dissipate energy.

Avoid and Minimize Wetland Disturbances: The following avoidance and minimization principles should be applied when considering wetland disturbances.

- Prohibit significant disturbance of unmitigatable wetlands.
- Demonstrate that there is no practical alternative to necessary wetland impacts.
- Minimize the wetland disturbance.

Require Mitigation for all Unavoidable Wetland Impacts: All unavoidable wetland impacts should be mitigated with the following order of preference.

- On site mitigation - Mitigation should occur on site, where possible, to preserve the water quality, aquatic habitat, and stormwater benefits on site.
- Perform mitigation within the same watershed - Where it is not feasible to provide wetland mitigation on site, wetland mitigation should occur within the same subwatershed (i.e., within Bear Creek subwatershed).
- Perform mitigation within same basin (i.e., within the Muskegon River Basin.
- Utilize a wetland bank. Where wetland banks exist, they may be used to prevent an overall loss of wetland resources.

Require Protection of Natural Stream Functions: Except when in accordance with other Plan objectives, modification of natural streams should be avoided except to perform stream restoration and maintenance activities consistent with watershed goals and objectives. Where avoidance is not feasible, environmental mitigation should be required.

Require Buffers Along All Waterbodies and Wetlands: A buffer of appropriate width comprised of native vegetation should be maintained or established along the edge of all streams, lakes, and wetlands. Exceptions to the native vegetation requirement may be allowed to facilitate water dependent activities, maintenance, or recreational access such as for beaches and boat launches, where appropriate. This standard is intended to minimize streambank and shoreline erosion, protect aquatic and riparian habitat, provide filtering of contaminated runoff, and preserve natural aesthetics.

Require Setbacks Along All Waterbodies and Wetlands: Beyond the buffer described above, a setback should be established along the edge of all streams, lakes, and wetlands. Only limited types of development should be allowed within the setback. The development types should be limited to the following:

- Minor improvements such as pedestrian or bicycle trails and educational signs.
- Maintenance access for utilities
- Parks and recreational areas
- Private and public lawns

This standard is recommended to provide a transition zone between intensive development and the natural features of the buffer. In addition to supporting the previously-stated objectives of a buffer, a setback is recommended for streams in recognition that erosion is a natural process and adequate setbacks are necessary to prevent erosion from threatening structures and their foundations. Setbacks also ease access for critical maintenance needs.

Soil Erosion and Sediment Control

Minimize the Area and Time of Disturbance: The area disturbed at any particular time and the duration of disturbance should be minimized through staging of construction activities and through site design which minimizes the area to be regraded.

Require Installation of Sediment Control Measures Prior to Land Disturbance: Sediment control measures such as sedimentation basins and silt fences should be installed prior to significant land disturbance activities to ensure that sediment generated during construction is captured.

Require Early Implementation of Erosion Control Measures: Soil erosion control measures such as temporary seeding, mulching, and erosion control blanket should be implemented soon after the end of active disturbance of the land and prior to final grading if final grading will not be completed for a significant period of time. This includes stabilization of soil stockpiles.

Require Routine Inspection and Maintenance of All Soil Erosion and Sediment Control Measures: For soil erosion and sediment control measures to be effective they must be routinely inspected and maintained. Although construction activities are only temporary, soil erosion and sediment control measures such as erosion blanket, silt fences, and sediment traps will commonly require maintenance or replacement several times during the construction process.

Provide Effective Enforcement Tools: Without adequate provisions for enforcement, it may be difficult to ensure that measures are adequately maintained. Effective enforcement tools include stop work orders and fines that specify each day as a separate violation and letters of credit that allow the enforcement agency to immediately address an issue using the developer's funds.

4.3 Stormwater Management Unit Recommendations

Stormwater management techniques applicable to most areas of the watershed were provided in **Chapter III** and watershed-wide ordinance standards were recommended in **Section 4.2**. This section provides recommendations for five physiographically consistent areas.

The Watershed was subdivided into five (5) management units. The units were subdivided based on proximity to stream and wetland resources, slope, depth to groundwater table, and hydrologic connectivity. The five areas are described briefly below and in more detail on subsequent pages. Five (5) levels of stormwater management are delineated based on levels of intensity, as shown on the next page.

- **Unit 1** is the Green Infrastructure Plan area identified in **Section 3.1**. The recommendations for this Unit are focused primarily on conservation and natural resources protection. Limited development is recommended.

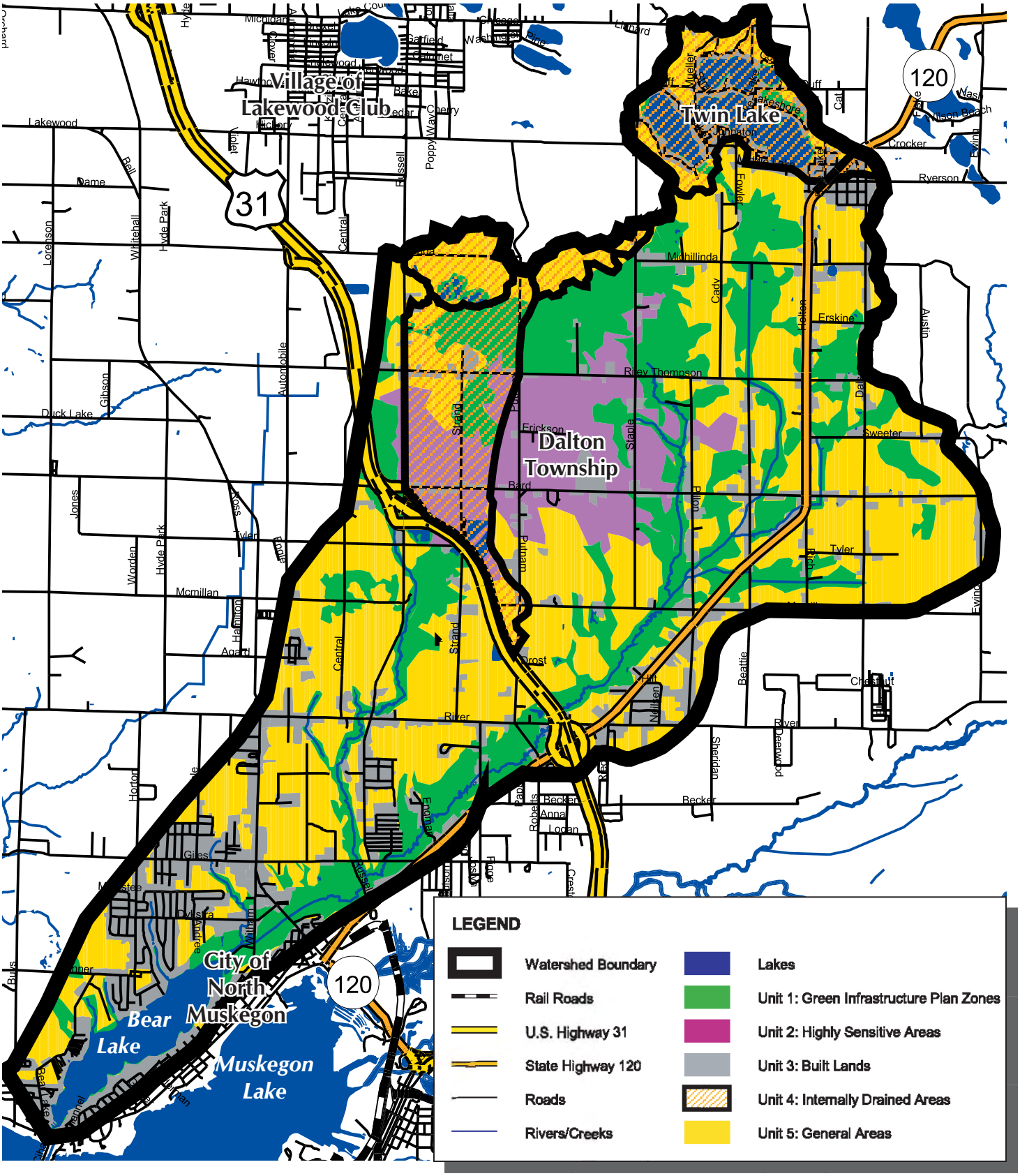
- **Unit 2** includes sensitive areas with hydric soils and/or water table less than 10 feet deep, in which groundwater protection is highly recommended. Restriction to certain development types is recommended for this Unit.

- **Unit 3** includes existing developed/built areas (based on 1997 conditions). The recommendations focus primarily on retrofitting stormwater BMPs.

- **Unit 4** includes internally drained areas where it is critical to maintain hydraulic isolation to protect downstream hydrology. The internally drained areas include the Twin Lakes area where special measures should be take to protect lake water quality.

- **Unit 5** represents areas excluding Units 1 to 4, in which general stormwater management measures and conservation site planning and design should be applied.

The following pages detail the general character, opportunities, constraints, and recommendations for each Management Unit. Watershed Goals and community Usage Goals based on the *319 Watershed Management Plan* have been referenced to illustrate how implementation of the stormwater management plan addresses the Watershed Management Plan Goals.



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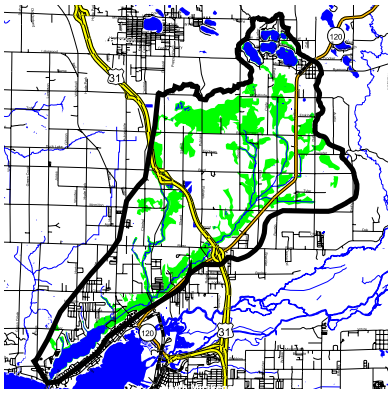
North

Watershed Stormwater Management Unit Recommendations Map

Stormwater Management Recommendations:

Management Unit 1

Green Infrastructure Plan Zones



Key Plan

General Condition

The purpose of this management unit is to protect against direct modification of watershed stream and wetland resources. The unit includes those natural resources and natural areas that are most sensitive to development and other disturbances. The natural features included are streams (and drains), lakes, wetlands, floodplains, hydric soils, buffer zones, steep slopes (>12%), and soils classified as highly erodible.

Opportunities/Benefits

- Protects against future flooding.
- Preserves floodplain hydrology, reducing streambank erosion potential and improving water quality.
- Preserves and enhances wildlife habitat connectivity.
- Potential to create interconnected recreational open space network

Constraints

- Development should be limited to passive recreation, including trails, canoe launches, and other development specifically intended to provide public access to stream reaches, wetlands, or lakes.
- No commercial or residential development should occur within this unit.

Recommendations

- Integrate Green Infrastructure Plan into municipal and county land use plans and open space zoning.
- Prepare flood profiles and floodplain boundaries based on flows developed in MDEQ Hydrologic Study and provide regulatory protection within flood boundaries. Update Plan based on new boundaries.
- Establish buffer and setback requirements for stream, lake, and wetland resources.
- Using Conservation Easements or fee simple purchase, acquire the most sensitive lands that cannot be adequately protected using other strategies.
- Develop and implement restoration management plans for lands within this management unit. The plans should consider hydrologic conditions, floodplain storage and conveyance, water quality, and wildlife habitat connectivity.
- Prepare public access plans, including trail networks, canoe launches, fishing access, etc.
- Expand Plan boundary to include upland remnant landscapes such as woodlands and prairies as well as significant cultural and historic resources.

Goals Addressed

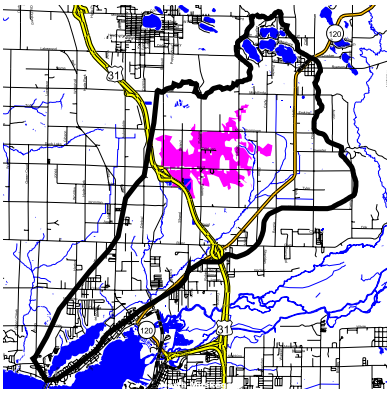
- Watershed Goals

☒ Goal 1: Improve surface/ground water quality to sustain cold-water fishery
☒ Goal 2: Restore aquatic life and wildlife habitat
☒ Goal 3: Restore both partial and total body contact designated uses
☒ Goal 4: Maintain a balance of the needs of the fishery with navigational uses
☒ Goal 5: Improve warm water fishery

- Watershed Usage Goals

☒ Goal 1: Ensure water quality
☒ Goal 2: Identify and protect critical habitat
☒ Goal 3: Establish permanent easements and nature preserves
☐ Goal 4: Clean up polluted areas
☒ Goal 5: Establish access sites along streams and lakes

conservation easements provide mechanism for long term protection of morphologically based corridors



Key Plan

Stormwater Management Recommendations:
Management Unit 2

Highly Sensitive Areas

General Condition

This Unit includes those area with a relatively shallow groundwater table as indicated by the presence of hydric soils. Due to the shallow groundwater table and sandy soils, land within this unit may be particularly sensitive to groundwater contamination. The hydric soil areas may also be suitable for wetland creation.

Goals Addressed

- Watershed Goals

☒ Goal 1: Improve surface/ground water quality to sustain cold-water fishery
☒ Goal 2: Restore aquatic life and wildlife habitat
☐ Goal 3: Restore both partial and total body contact designated uses
☐ Goal 4: Maintain a balance of the needs of the fishery with navigational uses
☒ Goal 5: Improve warm water fishery

- Watershed Usage Goals

☒ Goal 1: Ensure water quality
☐ Goal 2: Identify and protect critical habitat
☐ Goal 3: Establish permanent easements and nature preserves
☐ Goal 4: Clean up polluted areas
☐ Goal 5: Establish access sites along stream and lakes

Opportunities/Benefits

- Potential for wetland restoration/creation within hydric soil areas.
- Potential to increase Green Infrastructure Plan area and open space preservation.
- Opportunity to reduce potential for groundwater contamination

Constraints

- Development should be limited to those uses that do not involve production or handling of potentially hazardous materials.
- Practices that should not occur within this unit include storage of materials (including deicing compounds) that could come into contact with rainfall and therefore be washed off onto the land where it can contaminate groundwater.
- Consideration should be given to excluding automobile service stations where spills could occur during delivery.

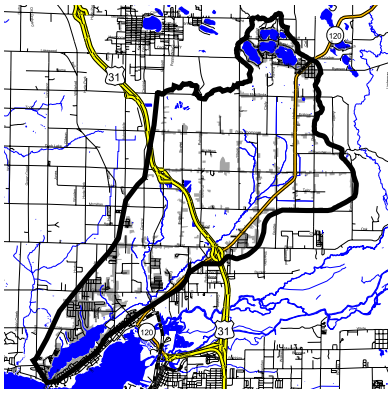
Recommendations

- Integrate "Highly Sensitive" Unit into municipal and county land use plans and provide adequate zoning to provide constraints outlined above.
- Zone specific septic and other on-site wastewater standards should be developed to ensure adequate treatment prior to release to the water table.
- Adopt stormwater management ordinances to prevent flooding, streambank erosion, and water quality degradation, and maintain groundwater hydrology.
- Promote conservation site planning and design.
- Implement stormwater management BMPs described in the Tool Box.
- Consider creating wetlands within hydric soil areas to increase watershed wetland resources.
- Restrict development within hydric soil areas to reduce potential for flooding and avoid structural and other problems associated with weak hydric soils.

Highly sensitive areas have greater potential for groundwater contamination and degradation of stream and wetland resources

Stormwater Management Recommendations:
Management Unit 3

Built Lands



Key Plan

General Condition

This Unit includes those areas of the watershed already developed into residential and commercial uses. The primary focus of the constraints and recommendations for this zone is to reduce water quality impacts from existing stormwater runoff.

Opportunities/Benefits

- Potential to reduce stormwater impacts from already developed areas.

Constraints

- It is generally more expensive to retrofit stormwater management measures than to integrated them into new development plans.
- Space for implementation of stormwater best management practices and stream and wetland restoration projects is often limited.

Recommendations

- Encourage redevelopment and infill projects to reduce overall development footprint on the watershed.
- Provide incentives for implementation of stormwater BMPs as part of redevelopment and infill projects.
- Pursue grants and other funding sources to plan and implement BMP retrofitting projects.
- Implement stormwater BMPs most applicable to retrofitting including:
  - **Downspout Disconnection:** Downspouts should not be connected directly to the storm sewer system and instead should discharge onto lawns or to rain gardens.
  - **Rain Gardens:** Rain gardens are an inexpensive landscaping technique that can be used to address runoff from residential lots. Use of native vegetation within the garden will ensure long term soil health and continued water quality performance.
  - **Naturalized Vegetated Swales:** Street drainage in many areas of the watershed is via open vegetated swales. Naturalizing these swales through establishment of native vegetation will improve retention of stormwater runoff and improve water quality treatment by increasing levels of soil organic carbon that is important for removing many stormwater pollutants.
  - **Parking Lot Bioswales:** Installation of depressed parking lot islands is a relatively simple retrofit during parking lot rehabilitation projects.

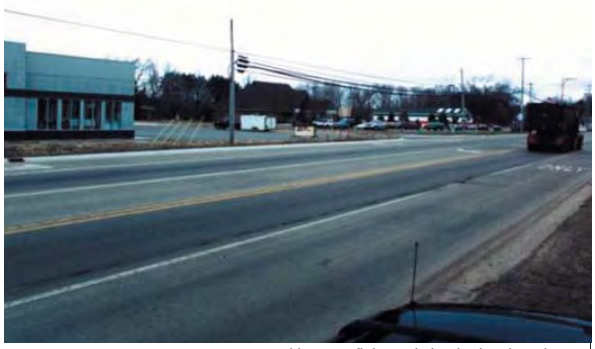
Goals Addressed

- Watershed Goals

☒ Goal 1: Improve surface/ground water quality to sustain cold-water fishery
☒ Goal 2: Restore aquatic life and wildlife habitat
☒ Goal 3: Restore both partial and total body contact designated uses
☐ Goal 4: Maintain a balance of the needs of the fishery with navigational uses
☒ Goal 5: Improve warm water fishery

- Watershed Usage Goals

☒ Goal 1: Ensure water quality
☐ Goal 2: Identify and protect critical habitat
☒ Goal 3: Establish permanent easements and nature preserves
☒ Goal 4: Clean up polluted areas
☒ Goal 5: Establish access sites along stream and lakes

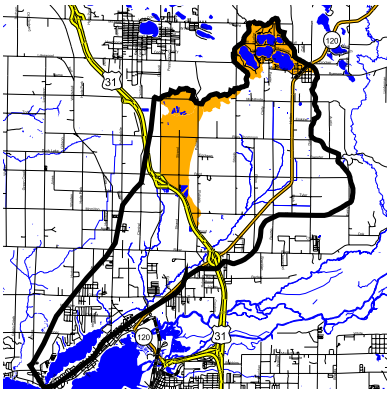

Numerous opportunities retrofitting existing in developed areas

- **Stream and Wetland Restoration:** streambank stabilization and restoration projects should be implemented to address degraded conditions and potential sediment sources

Stormwater Management Recommendations:

Management Unit 4

Internally Drained Areas



Key Plan

Goals Addressed

- Watershed Goals

☒ Goal 1: Improve surface/ground water quality to sustain cold-water fishery
☒ Goal 2: Restore aquatic life and wildlife habitat
☒ Goal 3: Restore both partial and total body contact designated uses
☒ Goal 4: Maintain a balance of the needs of the fishery with navigational uses
☒ Goal 5: Improve warm water fishery

- Watershed Usage Goals

☒ Goal 1: Ensure water quality
☒ Goal 2: Identify and protect critical habitat
☒ Goal 3: Establish permanent easements and nature preserves
☐ Goal 4: Clean up polluted areas
☒ Goal 5: Establish access sites along stream and lakes

General Condition

There are two large internally drained areas of the watershed that contribute no surface discharge to the remainder of the watershed. One area includes Twin Lakes and the surrounding neighborhood that is mostly low density residential development adjacent to the lakes. Because the lakes are drained only by groundwater outflow, they are "sinks" for the surrounding drainage area. Thus, they are vulnerable to contamination from both stormwater and groundwater sources.

Opportunites/Benefits

- Potential to maintain groundwater hydrology in watershed areas downstream of Unit 4.
- Continued high quality lake resources.

Constraints

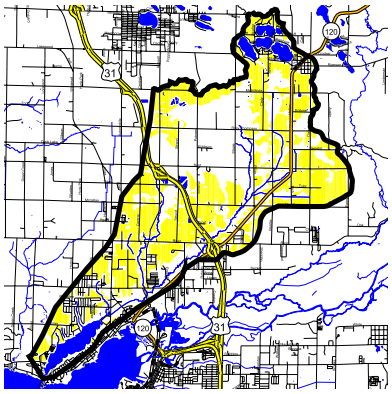
- Surface connections to the downstream watershed should be prohibited.
- New development and redevelopment within Twin Lakes area should be prohibited from increasing surface runoff to prevent increases in lake level fluctuations.

Recommendations

- Unit 4 is an overlay of the four other Management Units and the recommendations here are in addition to those of the underlying Units.
- Initiate lake monitoring program to identify lake problems and to assess water quality and biological health trends.
- Existing septic systems should be evaluated and updated as necessary to prevent discharge of essentially untreated wastewater to the water table and ultimately the lakes.
- Particular attention should be devoted to enforcing Soil Erosion and Sediment Control standards in the vicinity of the Twin Lakes portion of the watershed.
- Perform lakeshore stabilization and restoration using bio-engineering techniques to reduce shoreline erosion and improve water quality.
- The existing drainage system, largely composed of roadside ditches and swales, should be naturalized to improve retention and filtering of stormwater runoff. Implement other BMPs, such rain gardens and bioswales to reduce stormwater impacts.
- Create regulatory authority to prevent increases in runoff volumes associated with development and redevelopment to prevent surface water discharge to the downstream watershed.

Stormwater Management Recommendations:

Management Unit 5



Key Plan

General Areas

General Condition

This Unit includes those undeveloped areas of the watershed not already addressed under Units 1-4. The purpose of the standards for this Unit is to minimize development impacts as the watershed grows.

Opportunities/Benefits

- There is significant opportunity to prevent degradation of stream and wetland resources through implementation of preventive stormwater BMPs.

Constraints

- There are few constraints to development within this Unit except those imposed by recommended development standards and site specific constraints.

Recommendations

- Adopt stormwater management ordinances to prevent flooding, streambank erosion, and water quality degradation, and maintain groundwater hydrology.
- Promote conservation site planning and design.
- Implement stormwater management BMPs described in the Tool Box.
- Develop stormwater management manual and provide technical resources to facilitate implementation of recommended stormwater BMPs.
- Implement measures to prevent potentially hazardous materials from coming into contact with rainfall and runoff.

Goals Addressed

- Watershed Goals

☒ Goal 1: Improve surface/ground water quality to sustain cold-water fishery
☐ Goal 2: Restore aquatic life and wildlife habitat
☒ Goal 3: Restore both partial and total body contact designated uses
☐ Goal 4: Maintain a balance of the needs of the fishery with navigational uses
☒ Goal 5: Improve warm water fishery

- Watershed Usage Goals

☒ Goal 1: Ensure water quality
☐ Goal 2: Identify and protect critical habitat
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☐ Goal 4: Clean up polluted areas
☐ Goal 5: Establish access sites along stream and lakes


General areas shall follow conservation planning and design principles

conclusions and next steps V

5.1 Plan Summary

The Bear Creek and Bear Lake Watershed Stormwater Management Plan is a component of the Bear Creek and Bear Lake Watershed Management Plan and is intended to address existing and potential future stormwater impacts associated with development. The issues intended to be addressed by this plan are based on the assessment performed as part of the watershed management plan and the watershed goals and objectives. The watershed inventories and assessments were reviewed in **Chapter II** of this Plan.

General stormwater management strategies were identified in **Chapter III** to address identified stormwater management conditions. These strategies were presented in the form of a toolbox of policy, planning, and stormwater BMP strategies and templates that illustrate application of the strategies and practices on hypothetical development sites. Recommended stormwater standards were outlined in **Section 4.1**.

Due to physiographic differences within the watershed, the watershed was divided into five management units. Recommendations specific to the conditions within the five units were provided in **Section 4.2**.

5.2 Implementation Steps

To implement the strategies and recommendations identified in this plan, a five-pronged approach is suggested.

1) Incorporate Green Infrastructure Plan into municipal, township, and county comprehensive plans to provide protection against direct modification of stream and wetland resources of the watershed.

2) Prepare and adopt a watershed development ordinance that includes the recommendations of **Section 4.1** to provide protection against indirect impacts to stream and wetland resources caused by stormwater runoff. Also prepare a stormwater manual to support the ordinance.

3) Implement remedial measures to address runoff from existing developed areas, identified groundwater contamination sites, and potential on-site wastewater system (septic systems) impacts.

4) Implement a monitoring program to evaluate watershed health and the success of the implemented watershed protection strategies in achieving watershed goals. Update standards and strategies as necessary to address goals that are not being met.

5) Develop educational programs to educate citizens, local officials, and design professionals. Education for the general public should focus on actions that residents can take to reduce runoff from their own properties. Education for local officials should focus on providing tools to implement policies and programs to achieve the goals and objectives established for this watershed. Education for design professionals should focus on providing guidance on planning and stormwater management strategies for meeting the stormwater ordinance.

5.3 Institutional Framework

It should be recognized that watershed restoration and protection requires a sustained effort and funding to ensure that watershed goals are being achieved. To this end, an institutional framework is required. Institutional Framework recommendations include:

1) Create watershed Committee: Each of the municipalities, the County, and townships should have a representative on the Committee.

2) Create Advisory Committee(s): Committees to advise the Watershed Committee on technical, funding, and institutional matters should be created. Members of the advisory committees should include resource agencies, developers, consultants, real estate and business professionals, and local advocacy groups.

3) Develop Funding Mechanisms: Funding for implementation of the recommendations of this stormwater plan and the watershed management plan will likely come from multiple sources including general funds from each of the taxing bodies represented on the Watershed Committee, grants from state and federal agencies and foundations, and special service areas. User fee type funding mechanisms should also be considered to provide funding in proportion to need and to provide incentives for reducing stormwater impacts.

4) Develop Watershed Staff to Assist in Implementation of Recommendations: Staff should be hired to assist in implementation of the stormwater and watershed management plans and the directives from the Watershed Committee. Staff activities would include preparation and enforcement of the watershed development ordinance, technical assistance in meeting ordinance standards, ongoing monitoring of Plan implementation and success in meeting goals, and public outreach and educational activities.

references and resources

References

MCD, Draft 2002, Initial Water Quality Summary for Bear Creek/Lake 319 Watershed Management Plan.

MCD, 2002, Muskegon Lake Community Action Plan: 2002 Remedial Action Plan Update.

MDEQ and Michigan State University, 2000, Developing a Watershed Management Plan for Water Quality: An Introductory Guide.

MDEQ, 2003, Bear Creek Watershed Hydrologic Study.

NIPC and Chicago Wilderness, 2003, Conservation Design Resourcee Manual: Language and Guidelines for Updating Local Ordinance.

USDA, 1968, Soil Survey: Muskegon County, Michigan.

Stormwater BMPs Resources

Planning / Zoning

- Center for Watershed Protection, *Better Site Design*
  www.cwp.org/better_site_design.htm

- Langworthy Strader Leblanc & Associates,
  Inc. (LSL)
  15 Ionia SW, Suite 450
  Grand Rapids, MI, 49503
  (616) 336-7750
  www.lslplanning.com

- Michigan State University Extension
  Muskegon County
  635 Ottawa Street
  Muskegon, MI 49442
  (231)-724-6361
  www.msue.msu.edu/cplanner

Planning / Zoning (continued)

- Northerneastern Illinois Planning Commission (NIPC),
  Conservation Design Resource Manual
  www.nipc.cog.il.us
- Prince George's County Planning Department
  www.mncppc.org/pgco
- The Countryside Program
  www.countrysideprogram.org/
- West Michigan Shoreline Regional Development Commission (WMSRDC)
  316 Morris Avenue, Suite 340
  P.O. Box 387
  Muskegon, MI, 49443-0387
  (231) 722-7878
  www.wmsrdc.org

Stormwater BMPs

- Center for Watershed Protection, *Stormwater Manager's Resource Center*
  www.stormwatercenter.net
- Low Impact Development (LID) Center
  www.lowimpactdevelopment.org
- Maryland Stormwater Design Manual Volumes I & II, 2000.
  www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp
- Portland Stormwater Management Manual 2002
  www.cleanrivers-pdx.org/tech_resources/2002_swmm.htm
- Prince George's County Planning Department
  www.pgcounty.com/Government/AgencyIndex/DER/PPD/lid.asp?h=&s=&n=50&n1=160
- Green Roofs
  Greenroofs.com
  www.greenroofs.com
  Green Roofs for Healthy Cities
  www.peck.ca/grhcc
  Pennsylvania State University, Center for Green Roof Research
  http://hortweb.cas.psu.edu/research/greenroofcenter/

Stormwater BMPs (continued)

- Rainwater Garden

  Rain Gardens of West Michigan
  West Michigan Environmental Action Council
  1514 Wealthy SE, Suite 280
  Grand Rapids, MI, 49506
  (616) 454-RAIN
  www.raingardens.org/our_history.php

- Porous Pavement

  Paveloc Ltd.
  www.paveloc.com

  Unilock Ltd.
  www.unilock.com

Landscaping

- Native Landscaping

  Chicago Wilderness
  www.chicagowilderness.org/wildchi/landscape/index.cfm

  EPA
  www.epa.gov/glnpo/greenacres/
  nativeplants

  Master Gardener Association – Michigan State University Extension
  635 Ottawa Street
  Muskegon, MI, 49442-1016
  (231) 724-6361
  www.muskegonmastergardenders.org

- Timberland RC&D
  6655 Alpine Avenue
  NW Comstock Park, MI, 49321-8325
  (616) 784-1090

- West Michigan Environmental Action Council (WMEAC)
  1514 Wealthy SE, Suite 280
  Grand Rapids, MI, 49506
  (616) 451-3051
  www.wmeac.org

Other Resources

- The Muskegon Conservation District
  101 East Wesley Avenue, Room 6
  Muskegon, MI, 49442
  (231) 773-0008
  www.muskegoncd.org

- Conservation Design Forum
  375 W. First Street
  Elmhurst, IL, 60126
  (630) 559-2000
  www.cdfinc.com

- Conservation Research Institute
  375 W. First Street
  Elmhurst, IL, 60126
  (630) 559-2045
  www.conservationresearchinstitute.org